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SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

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 noted.

B. Galvanized-Steel Wall Pipes: ASTM A53/A53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated with plain ends.


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

2.02 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 NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
   2. Pressure Plates: Carbon steel, plastic, stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.03 GROUT


B. Description: Nonshrink, 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.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal 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.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.02 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.

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

   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:

5. Interior Partitions:

END OF SECTION
SECTION 21 0518
ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated and polished brass finish and setscrew fastener.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.
C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

2.02 FLOOR PLATES

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

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.
      b. Chrome-Plated Piping: One-piece, cast brass with polished, chrome-plated finish.
      c. Insulated Piping: One-piece stamped steel type.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel type.
      f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
      g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped brass type.
      h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated or rough-brass finish.
      i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-brass type.
      j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated or rough-brass finish.
      k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.

3.02 FIELD QUALITY CONTROL

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

END OF SECTION
SECTION 21 0523

GENERAL-DUTY VALVES FOR FIRE PROTECTION PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Iron butterfly valves with indicators.
   2. Check valves.
   3. Iron OS&Y gate valves.
   4. NRS gate valves.
   5. Indicator posts.
   6. Trim and drain valves.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
   1. Main Level: HAMV - Fire Main Equipment.
      a. Level 1: HCBZ - Indicator Posts, Gate Valve.
      b. Level 1: HLOT - Valves.
         1) Level 3: HLUG - Ball Valves, System Control.
         2) Level 3: HLXS - Butterfly Valves.
         3) Level 3: HMER - Check Valves.
         4) Level 3: HMRZ - Gate Valves.
      a. Level 1: VQGU - Valves, Trim and Drain.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
   1. Automated Sprinkler Systems:
      a. Indicator posts.
      b. Valves.
         1) Gate valves.
         2) Check valves.
            a) Single check valves.
            3) Miscellaneous valves.

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

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

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

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

G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.
H. Valve Sizes: Same as upstream piping unless otherwise indicated.

I. Valve Actuator Types:
1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.02 IRON BUTTERFLY VALVES WITH INDICATORS

A. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
3. Body Material: Cast or ductile iron.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, and EPDM.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.

2.03 CHECK VALVES

A. Description:
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.

2.04 IRON OS&Y GATE VALVES

A. Description:
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.

2.05 NRS GATE VALVES

A. Description:
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: [Flanged] [Grooved] [Threaded].

2.06 INDICATOR POSTS

A. Description:
   2. Type: Wall.
   3. Base Barrel Material: Cast or ductile iron.
   4. Extension Barrel: Cast or ductile iron.
   5. Cap: Cast or ductile iron.

2.07 TRIM AND DRAIN VALVES

A. Angle Valves:
   1. Description:
      b. Body Material: Brass or bronze.
      c. Ends: Threaded.
      d. Stem: Bronze.
      e. Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

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

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

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

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

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

F. Install valve tags.

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

END OF SECTION
SECTION 21 0529
HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS
A. Welding certificates.

1.04 QUALITY ASSURANCE
A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
D. UL Compliance: Comply with UL 203.

2.02 METAL PIPE HANGERS AND SUPPORTS
A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
   2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
B. Copper Pipe and Tube Hangers:
   1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.

2.03 TRAPEZE PIPE HANGERS

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

2.04 THERMAL HANGER-SHELTER INSERTS

A. Insulation-Insert Material: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi minimum compressive strength.

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

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

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

2.05 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

   1. Indoor Applications: Stainless steel.
   2. Outdoor Applications: Stainless steel.

2.06 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.07 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, 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 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.02 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

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


G. 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.

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

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

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

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

L. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal Hanger Shields: Install with insulation of 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 bearing surface smooth.
   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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.05 ADJUSTING
   A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
   B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches dimension.

3.06 PAINTING
   A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
      1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
   B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal.
   C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.07 HANGER AND SUPPORT SCHEDULE
   A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
   B. Comply with NFPA requirements 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 finishes.

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

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

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

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

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

I. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
   3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
   5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
   6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
   7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
   8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
   9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

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

K. Hanger-Rod Attachments: Comply with NFPA requirements.

L. Building Attachments: Comply with NFPA requirements. 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. C-Clamps (MSS Type 23): For structural shapes.
   3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

M. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
N. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 21 0553
IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

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

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, with predrilled holes for attachment hardware.
   2. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   4. 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. Fasteners: Stainless-steel rivets or self-tapping screws.
   6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

C. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

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

B. Letter Color: Black or Blue or Red or White or Yellow

C. Background Color: Black or Blue or Red or White or Yellow

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

2.03 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 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 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 LABEL INSTALLATION REQUIREMENTS

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

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

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

D. Locate equipment labels where accessible and visible.

E. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit a 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.

END OF SECTION
SECTION 21 1119
FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Exposed-type fire-department connections.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.01 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION
A. Standard: UL 405.
B. Type: Exposed, projecting, for wall mounting.
C. Pressure Rating: 175 psig minimum.
D. Body Material: Corrosion-resistant metal.
E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
F. Caps: Brass, lugged type, with gasket and chain.
G. Escutcheon Plate: Round, brass, wall type.
H. Outlet: Back, with pipe threads.
I. Number of Inlets: Two.
J. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
K. Finish: Polished chrome plated.
L. Outlet Size: NPS 4.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Install wall-type fire-department connections.
B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Cover system for sprinkler piping.
4. Sprinklers.
6. Pressure gages.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

C. Shop Drawings: For wet-pipe sprinkler systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which items of other systems and equipment are shown and coordinated with each other, using input from installers of the items involved.

B. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

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

D. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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

B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 “Quality Requirements,” to design wet-pipe sprinkler systems.
   1. Available fire-hydrant flow test records indicate the following conditions:
      a. Date: test date.
      b. Time: time a.m. or p.m.
      c. Performed by operator's name or firm.
      d. Location of Residual Fire Hydrant R: location.
      e. Location of Flow Fire Hydrant F: location.
      f. Static Pressure at Residual Fire Hydrant R: psig.
      h. Residual Pressure at Residual Fire Hydrant R: psig.

2. Sprinkler system design shall be approved by authorities having jurisdiction.
   a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.02 STEEL PIPE AND FITTINGS

A. Standard-Weight Galvanized- and or Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30 Galvanized- and or Black-Steel Pipe: ASTM A 135/A 135M; ASTM A 795/A 795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Thinwall Galvanized- and or Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

D. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

E. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M thinwall with plain ends and wall thickness less than Schedule 10.

F. Hybrid Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.

G. Schedule 5 Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M lightwall with plain ends.


J. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

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

M. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
   1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch-thick or ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
      b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

N. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Pressure Rating: 175-psig or 250-psig or 300-psig minimum.
   2. Galvanized or Painted or Uncoated Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
   3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

O. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

2.03 COVER SYSTEM FOR SPRINKLER PIPING

   A. Description: System of support brackets and covers made to protect sprinkler piping.
   B. Brackets: Glass-reinforced nylon.
   C. Covers: Extruded-PVC sections of length, shape, and size required for size and routing of CPVC piping.

2.04 SPECIALTY VALVES

   A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
   B. Specialty Valves Pressure Rating: 175-psig minimum.
   C. Body Material: Cast or ductile iron.
   D. Size: Same as connected piping.
   E. End Connections: Flanged or grooved.
   F. Alarm Valves:
      2. Design: For horizontal or vertical installation.
      3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
      4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
      5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
   G. Automatic (Ball Drip) Drain Valves:
      3. Type: Automatic draining, ball check.
      5. End Connections: Threaded.

2.05 SPRINKLER PIPING SPECIALTIES

   A. Branch Outlet Fittings:
      2. Pressure Rating: 175-psig minimum or 300 psig.
      4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:
2. Pressure Rating: 175-psig minimum or 300 psig.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:
2. Pressure Rating: 175-psig minimum 300 psig.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:
2. Pressure Rating: 250-psig minimum or 300 psig.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

2.06 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Automatic Sprinklers with Heat-Responsive Element:
2. Nonresidential Applications: UL 199.
3. Residential Applications: UL 1626.
4. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

E. Sprinkler Finishes: White painted.

F. Special Coatings: Wax or polyester.

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

H. Sprinkler Guards:
1. Manufacturer: Sprinkguard
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.07 MANUAL CONTROL STATIONS
A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.
B. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.08 PRESSURE GAGES
A. Standard: UL 393.
B. Dial Size: 4-1/2-inch diameter.
C. Pressure Gage Range: 0- to 250-psig minimum.
D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.01 SERVICE-ENTRANCE PIPING
A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.
B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.
C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.02 WATER-SUPPLY CONNECTIONS
A. Connect sprinkler piping to building's interior water-distribution piping.
B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping.
C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.03 PIPING INSTALLATION
A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
   2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.
D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

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

H. Install sprinkler piping with drains for complete system drainage.

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

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

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

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

N. Fill sprinkler system piping with water.

O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing.

P. Install sleeves for piping penetrations of walls, ceilings, and floors.

Q. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

3.04 JOINT CONSTRUCTION

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

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

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

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

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

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

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

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

H. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

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

K. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

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

3.05 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 for supports.

3.06 VALVE AND SPECIALTIES INSTALLATION

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

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

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

D. Specialty Valves:
   1. Install valves in vertical position for proper direction of flow, in main supply to system.
   2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
   3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.07 SPRINKLER INSTALLATION

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

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

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.08 IDENTIFICATION

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

B. Identify system components, wiring, cabling, and terminals.

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

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

C. Prepare test and inspection reports.

3.010 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.011 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized.

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

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller shall be one of the following:
   1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 6 shall be one of the following:
   1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Thinwall or Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.012 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
   1. Rooms without Ceilings: Upright brass sprinklers.
   2. Rooms with Suspended Ceilings: Concealed sprinklers.

END OF SECTION
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 alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.02 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 NEMA MG 1 unless otherwise indicated.

2.02 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 5280 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: Premium efficient, as defined in NEMA MG 1.
C. Service Factor: 1.15.
D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.
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 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

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. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   3. 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 Applicable)

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

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

2.03 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.
C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 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.
E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.02 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.

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

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

4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or PVC-pipe.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or PVC-pipe.

5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or PVC-pipe.

END OF SECTION
SECTION 22 0518

ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.02 FLOOR PLATES

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

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 insulated piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
      g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
      h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated rough-brass finish.
      i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
      j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated rough-brass finish.
      k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.

3.02 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION
SECTION 22 0519
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

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

1.02 SUMMARY
   A. Section Includes:
      1. Bimetallic-actuated thermometers.
      2. Liquid-in-glass thermometers.
      3. Thermowells.
      4. Dial-type pressure gages.
      5. Gage attachments.

1.03 ACTION SUBMITTALS
   A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
   B. Product Data: For each type of product.

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

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

PART 2 - PRODUCTS

2.01 BIMETALLIC-ACTUATED THERMOMETERS
   B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
   C. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
   D. Ring: Stainless steel.
   E. Element: Bimetal coil.
   F. Pointer: Dark-colored metal.
   G. Accuracy: Plus or minus 1.5 percent of scale range.

2.02 LIQUID-IN-GLASS THERMOMETERS
   A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
      2. Case: Cast aluminum; 6-inch nominal size.
      3. Case Form: Back angle unless otherwise indicated.
      4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Stem: Aluminum or brass and of length to suit installation.
   a. Design for Thermowell Installation: Bare stem.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.03 THERMOWELLS

A. Thermowells:
   2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   3. Material for Use with Copper Tubing: CUNI.
   4. Material for Use with Steel Piping: CSA.
   5. Type: Stepped shank unless straight or tapered shank is indicated.
   8. Bore: Diameter required to match thermometer bulb or stem.
   9. Insertion Length: Length required to match thermometer bulb or stem.
   10. Lagging Extension: Include on thermowells for insulated piping and tubing.
   11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.04 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   2. Case: Sealed; cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
   3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   4. Pressure Connection: Brass, with ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   5. Movement: Mechanical, with link to pressure element and connection to pointer.
   8. Window: Glass.
   10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.05 GAGE ATTACHMENTS

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

B. Valves: Brass or stainless-steel needle, with ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.01 INSTALLATION

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

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

C. Install thermowells with extension on insulated piping.
D. Fill thermowells with heat-transfer medium.
E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
H. Install remote-mounted pressure gages on panel.
I. Install valve and snubber in piping for each pressure gage for fluids.
J. Install thermometers in the following locations:
   1. Inlet and outlet of each water heater.
   2. Inlets and outlets of each domestic water heat exchanger.
   3. Inlet and outlet of each domestic hot-water storage tank.
   4. Inlet and outlet of each remote domestic water chiller.
K. Install pressure gages in the following locations:
   1. Building water service entrance into building.
   2. Inlet and outlet of each pressure-reducing valve.
   3. Suction and discharge of each domestic water pump.
L. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
M. Adjust faces of meters and gages to proper angle for best visibility.

3.02 THERMOMETER SCALE-RANGE SCHEDULE
A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.
B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F.

3.03 PRESSURE-GAGE SCALE-RANGE SCHEDULE
A.
A. Scale Range for Water Service & Domestic Water Piping: 0 to 160 psi.

END OF SECTION
SECTION 22 0523
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
1. Brass ball valves.
2. Bronze ball valves.
4. Bronze swing check valves.
5. Iron swing check valves.
6. Iron swing check valves with closure control.
8. Bronze globe valves.
10. Chainwheels.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of valve indicated.

1.03 QUALITY ASSURANCE
A. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
B. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES
A. Refer to valve schedule articles for applications of valves.
B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
C. Valve Sizes: Same as upstream piping unless otherwise indicated.
D. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
F. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.
2.02 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Forged brass.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Brass.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

2.03 BRONZE BALL VALVES

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

1. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

B. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:

1. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Regular.

2.04 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

1. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: NBR.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.
2.05 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
   1. **Description:**
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      e. Ends: Threaded.
      f. Disc: Bronze.

   B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
      1. **Description:**
         a. Standard: MSS SP-80, Type 4.
         b. CWP Rating: 200 psig.
         c. Body Design: Horizontal flow.
         e. Ends: Threaded.
         f. Disc: PTFE or TFE.

2.06 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
   1. **Description:**
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

2.07 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves:
   1. **Description:**
      a. Standard: MSS SP-70, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Disc: Solid wedge.
      g. Packing and Gasket: Asbestos free.

2.08 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
   1. **Description:**
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      d. Ends: Threaded or solder joint.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze, or aluminum.

   B. Class 125, Bronze Globe Valves with Nonmetallic Disc:
      1. **Description:**
2.09 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

2.010 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to butterfly valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc coating.

PART 3 - EXECUTION

3.01 VALVE INSTALLATION

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

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

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

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

E. Install chainwheels on operators for butterfly and globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

1. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

3.02 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.

3.03 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball and butterfly valves.

2. Throttling Service: Globe valves.

3. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring.
c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

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

3.04 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Bronze[ and Brass] Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125, [bronze] [nonmetallic] disc.
3. Ball Valves: [One] [Two] piece, full port, [brass] [or] [bronze] with [brass] [bronze] trim.
4. Bronze Swing Check Valves: [Class 125], [bronze] [nonmetallic] disc.
5. Bronze Globe Valves: Class 125, [bronze] [nonmetallic] 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.
3. Iron Swing Check Valves: Class 125, [metal] [nonmetallic-to-metal] seats.
4. Iron Swing Check Valves with Closure Control: Class 125, lever and [spring] [weight].
5. Iron Gate Valves: [Class 125], [NRS] [OS&Y].

3.05 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two-piece, full port, [brass] [or] [bronze] with [brass] [bronze] trim.
3. Bronze Swing Check Valves: Class 125, [bronze] [nonmetallic] disc.
4. Bronze Globe Valves: Class 125, [bronze] [nonmetallic] 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 Swing Check Valves: Class 125, [metal] [nonmetallic-to-metal] seats.
3. Iron Swing Check Valves with Closure Control: Class 125, lever and [spring] [weight].
4. Iron Gate Valves: Class 125, [NRS] [OS&Y].

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.04 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless-steel.
2.02 TRAPEZE PIPE HANGERS
A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 THERMAL HANGER-SHIELD INSERTS
A. Insulation-Insert Material for Cold & Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.
B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.04 FASTENER SYSTEMS
A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

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

2.07 MATERIALS
A. Aluminum: ASTM B221.
B. Carbon Steel: ASTM A1011/A1011M.
C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.
D. Stainless Steel: ASTM A240/A240M.
E. Grout: ASTM C1107/C1107M, 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 INSTALLATION
A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

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

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


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

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

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

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

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

M. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
   5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.
3.02 EQUIPMENT SUPPORTS
   A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
   B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
   C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS
   A. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
   B. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
      1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
      2. Obtain fusion without undercut or overlap.
      3. Remove welding flux immediately.
      4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING
   A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
   B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.05 PAINTING
   A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.06 HANGER AND SUPPORT SCHEDULE
   A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
   B. Comply with MSS SP-58 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 finishes.
   D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
   E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
   F. Use stainless-steel pipe hangers and stainless-steel[or corrosion-resistant attachments for hostile environment applications.
   G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
   H. Use thermal hanger-shield inserts for insulated piping and tubing.
I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
3. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
4. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
5. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
6. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
7. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.

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

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

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

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

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

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. 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.

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

1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
2. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

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

END OF SECTION
SECTION 22 0553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for 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: Anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
2.02 WARNING SIGNS AND LABELS
A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch and 1/8 inch thick, and having predrilled holes for attachment hardware.
B. Letter Color: Black.
C. Background Color: Yellow.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters 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 Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1/2 inch high.

PART 3 - EXECUTION
3.01 PREPARATION
A. Clean piping and equipment surface 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. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 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: Green

2. Sanitary Waste, Vent, and Storm Drainage Piping:
   a. Background Color: Green
   b. Letter Color: White

3. Natural or LP Gas Piping:
   a. Background Color: Yellow
   b. Letter Color: Black

END OF SECTION
SECTION 22 0719
PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Sanitary waste piping exposed to freezing conditions.
   5. Storm-water piping exposed to freezing conditions.
   6. Roof drains and rainwater leaders.
   7. Supplies and drains for handicap-accessible lavatories and sinks.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.

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

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.
   1. Special-Shaped Insulation: ASTM C 552, Type III.
   2. Preformed Pipe Insulation: Type II, Class 1, without jacket.
3. Preformed Pipe Insulation with factory-applied ASJ or ASJ-SSL jacket. Comply with ASTM C 552, Type II, Class 2.
4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.

1. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket or with factory-applied ASJ or with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.02 INSULATION CEMENTS

2.03 ADHESIVES
A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
   1. For indoor applications, adhesive shall have a VOC content of 50g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.04 MASTICS
A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
B. Vapor-Barrier Mastic: Water Based; Suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM E96/E96M, 1.8 perm at 0.0625 inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 60 percent by volume and 66 percent by weight.

2.05 SEALANTS
A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
B. Joint Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.

C. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.06 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 C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.07 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White or Color-code jackets based on system. Color as selected by Architect.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.08 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. 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 C1136.
1. Width: 3 inches.
2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

2.09 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. 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.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.
J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
   3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 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.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 25 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 in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.

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 Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistant joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.04 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 2 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, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
   2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
   3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
   4. When covers are made from block insulation, make two 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.

3.05 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of 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 that of 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.
3.06 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands
      without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-
      barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-
      clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal
      tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material
      manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness
      of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent
      straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch,
      and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as that of straight segments of pipe insulation when
      available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe
      insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or
      bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as that of straight segments of pipe insulation when
      available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing
      insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-
   applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-
      barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal
   with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish
      bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints.
   Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant.
recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.08 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.09 FIELD QUALITY CONTROL

A. Perform tests and inspections.

3.010 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.

3.011 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.

3.012 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold, Hot and Recirculated Hot Water: Insulation shall be one of the following:
   1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Stormwater and Overflow: Insulation shall be one of the following:
   1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Roof Drain and Overflow Drain Bodies: Insulation shall be one of the following:
   1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.013 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. Piping, Concealed or Mechanical Spaces:
   1. None.

D. Piping, Exposed Occupied Areas:
   1. PVC 30 mils thick, color by architect.

END OF SECTION
SECTION 22 1116
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Copper tube and fittings.
2. Piping joining materials.
3. Transition fittings.
4. Dielectric fittings.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For transition fittings and dielectric fittings.

1.03 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

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

B. Potable-water piping and components shall comply with NSF 14, NSF 61 Annex G. Plastic piping components shall be marked with “NSF-pw”. and NSF 372. [Include marking “NSF-pw” on piping.]

2.02 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
F. Copper Unions:
   1. MSS SP-123.
   4. Solder-joint or threaded ends.

2.03 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
B. Standard-Pattern, Mechanical-Joint Fittings:
1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:
1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.04 PIPING JOINING MATERIALS

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

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

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

D. Flux: ASTM B 813, water flushable.

2.05 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

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

2.06 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 Flanges:
2. Factory-fabricated, bolted, companion-flange assembly.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Insulating Kits:
1. Nonconducting materials for field assembly of companion flanges.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

D. Dielectric Nipples:
2. Electroplated steel nipple complying with ASTM F 1545.
3. Pressure Rating and Temperature: 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.
PART 3 - EXECUTION

3.01 EARTHWORK

A. Comply with requirements for excavating.

3.02 PIPING INSTALLATION

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

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

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

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance.

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

F. Install water-pressure-reducing valves downstream from shutoff valves.

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

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

I. Install seismic restraints on piping.

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

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

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

M. Install piping to permit valve servicing.

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

O. Install piping free of sags and bends.

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

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

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump.

S. Install thermostats in hot-water circulation piping.

T. Install thermometers on inlet and outlet piping from each water heater.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

V. Install sleeve seals for piping penetrations of concrete walls and slabs.
W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.03 JOINT CONSTRUCTION

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

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

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

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

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

3.04 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

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

3.05 DIELECTRIC FITTING INSTALLATION

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

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

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

3.06 INSTALLATION OF HANGERS AND SUPPORTS

A. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer’s written instructions.

3.07 CONNECTIONS

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

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

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

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

A. Identify system components.

B. Label pressure piping with system operating pressure.

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

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

2. Piping Tests:
   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
   f. Prepare reports for tests and for corrective action required.

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

C. Prepare test and inspection reports.

3.010 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.
3.011 CLEANING

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

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

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

3.012 PIPING SCHEDULE

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

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

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

D. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K, wrought-copper, solder-joint fittings; and brazed joints.
   2. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

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

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

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

END OF SECTION
SECTION 22 1119
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

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

1.02 SUMMARY
A. Section Includes:
   1. Vacuum breakers.
   2. Backflow preventers.
   5. Temperature-actuated, water mixing valves.
   7. Hose bibbs.
   8. Wall hydrants.
  10. Water-hammer arresters.
  11. Trap-seal primer valves.

1.03 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.04 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES
A. Potable-water piping and components shall comply with NSF 61.
B. Comply with NSF 372 for low lead.

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

2.03 VACUUM BREAKERS
A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Inlet and Outlet Connections: Threaded.
   5. Finish: Chrome plated.
B. Hose-Connection Vacuum Breakers:
   2. Body: Bronze, nonremovable, with manual drain.
4. Finish: Chrome plated.

2.04 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
   5. Finish: Chrome plated.

B. Reduced-Pressure-Principle Backflow Preventers:
   2. Operation: Continuous-pressure applications.
   3. Pressure Loss: 12 psig maximum, through middle third of flow range.
   4. Accessories:
      a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
      b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

C. Double-Check, Backflow-Prevention Assemblies:
   2. Operation: Continuous-pressure applications unless otherwise indicated.
   3. Pressure Loss: 5 psig maximum, through middle third of flow range.
   4. Accessories:
      a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
      b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

2.05 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   2. Pressure Rating: Initial working pressure of 150 psig.

2.06 BALANCING VALVES

A. Memory-Stop Balancing Valves:
   2. Pressure Rating: 400-psig minimum CWP.
   3. Size: NPS 2 or smaller.
   4. Body: Copper alloy.
   5. Port: Standard or full port.
   7. Seats and Seals: Replaceable.
   8. End Connections: Solder joint or threaded.

2.07 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:
   3. Type: Thermostatically controlled, water mixing valve.
   5. Connections: Threaded union inlets and outlet.
   6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
B. Primary, Thermostatic, Water Mixing Valves:
   2. Pressure Rating: 125 psig minimum unless otherwise indicated.
   5. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

2.08 STRainers FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations unless otherwise indicated.
   5. Drain: Hose-end drain valve.

2.09 HOSE BIBBS

A. Hose Bibbs:
   4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
   8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
   10. Finish for Finished Rooms: Chrome or nickel plated.
   11. Operation for Equipment Rooms: Wheel handle or operating key.
   14. Include operating key with each operating-key hose bibb.
   15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.010 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:
   3. Operation: Loose key.
   4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
   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. Box: Deep, flush mounted with cover.
   8. Box and Cover Finish: Chrome plated.
   10. Operating Keys(s): One with each wall hydrant.

B. Nonfreeze, Hot- and Cold-Water Wall Hydrants:
   3. Operation: Loose key.
   4. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Chrome plated.
9. Vacuum Breaker:
   a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7 on outlet.
10. Operating Key(s): One with each wall hydrant.

C. Vacuum Breaker Wall Hydrants:
1. Standard: ASSE 1019, Type A or Type B.
2. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
3. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Operation: Loose key.
6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 1/2 or NPS 3/4.

2.011 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.

2.012 WATER -HAMMER ARRESTORS
A. Water-Hammer Arresters:
2. Type: Copper tube with piston.
3. Size: ASSE 1010, Sizes AA and A through F.

2.013 TRAP-SEAL PRIMER DEVICE
A. Supply-Type, Trap-Seal Primer Device:
4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Device:
2. Size: NPS 1-1/4 minimum.
PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Water Regulators: Install with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gauges on inlet and outlet.

C. Balancing Valves: Install in locations where they can easily be adjusted.

D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Y-Pattern Strainers: For water, install on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

F. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

G. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

3.02 CONNECTIONS

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

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

C. Comply with requirements for grounding equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.03 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Pressure vacuum breakers.
   2. Intermediate atmospheric-vent backflow preventers.
   3. Reduced-pressure-principle backflow preventers.
   5. Carbonated-beverage-machine backflow preventers.
   7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
  10. Automatic water shutoff valves.
  11. Calibrated balancing valves.
  12. Primary, thermostatic, water mixing valves.
15. Primary water tempering valves.
16. Outlet boxes.
17. Hose stations.
18. Supply-type, trap-seal primer valves.
19. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly, and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device’s reference standard.

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

C. Prepare test and inspection reports.

3.05 ADJUSTING

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

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION
SECTION 22 1316
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   2. Copper tube and fittings.
   3. ABS pipe and fittings.
   4. PVC pipe and fittings.
   5. Specialty pipe fittings.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS
A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS
A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS
A. Pipe and Fittings: ASTM A 74, Service class.
B. Gaskets: ASTM C 564, rubber.

2.03 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS
A. Pipe and Fittings: ASTM A 888 or CISPI 301.
C. CISPI, Hubless-Piping Couplings:
   2. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
D. Heavy-Duty, Hubless-Piping Couplings:
   2. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
E. Cast-Iron, Hubless-Piping Couplings:
   2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.
2.04 COPPER TUBE AND FITTINGS
   A. Copper Type DWV Tube: ASTM B 306, drainage tube, drawn temper.
   B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
   C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.05 COUPLING BELOW GRADE OR CRITICAL AREAS
   A. Hubless-Piping Couplings(made in USA):
      1. Manufacturers:
         a. Husky SD 4000 or equivalent.
         b. All band sizes shall have a minimum 4 straps (larger bands may have 6 straps)

2.06 PVC PIPE AND FITTINGS
   B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
   C. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
   D. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
   E. Adhesive Primer: ASTM F 656.

2.07 SPECIALTY PIPE FITTINGS
   A. Transition Couplings:
      1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
      2. Unshielded, Nonpressure Transition Couplings:
         b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
         c. End Connections: Same size as and compatible with pipes to be joined.
         d. Sleeve Materials:
            2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
            3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
      3. Shielded, Nonpressure Transition Couplings:
         b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
         c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.01 EARTH MOVING
   A. Comply with requirements for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping.

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
   2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
      a. Straight tees, elbows, and crosses may be used on vent lines.
   3. Do not change direction of flow more than 90 degrees.
   4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
      a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.
   1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
   2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
   3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Waste: 2.08 percent downward in direction of flow for piping NPS 3 and smaller; 1.04 percent downward in direction of flow for piping NPS 4 and larger.
   2. Vent Piping: 1percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

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

P. Install aboveground ABS piping according to ASTM D 2661.

Q. Install aboveground PVC piping according to ASTM D 2665.

R. Install underground PVC piping according to ASTM D 2321.

S. Plumbing Specialties:
   1. Install backwater valves in sanitary waster gravity-flow piping.
2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
3. Install drains in sanitary waste gravity-flow piping.

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

U. Install sleeves for piping penetrations of walls, ceilings, and floors.
V. Install sleeve seals for piping penetrations of concrete walls and slabs.
W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.03 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI’s “Cast Iron Soil Pipe and Fittings Handbook” for compression joints.
B. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
C. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
D. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
   3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in ODs.

3.05 VALVE INSTALLATION

A. Shutoff Valves:
   1. Install shutoff valve on each sewage pump discharge.
   2. Install gate or full-port ball valve for piping NPS 2 and smaller.
   3. Install gate valve for piping NPS 2-1/2 and larger.
B. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
C. Backwater Valves: Install backwater valves in piping subject to 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.

3.06 INSTALLATION OF HANGERS AND SUPPORTS

A. Support piping and tubing according to MSS SP-58 and manufacturer’s written instructions.
   1. a. Install carbon-steel pipe hangers for piping in noncorrosive environment.
      b. Install stainless-steel pipe support clamps for piping in corrosive environments.
3.07 CONNECTIONS

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

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:
   1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Install horizontal backwater valves with cleanout cover flush with floor in pit with pit cover flush with floor.
   6. Equipment: Connect waste piping as indicated.
      a. Provide shutoff valve if indicated and union for each connection.
      b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

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

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

3.08 FIELD QUALITY CONTROL

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

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

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
      a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
      a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
      b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
      c. Inspect joints for leaks.
4. **Finished Plumbing Test Procedure:** After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
   a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.09 **CLEANING AND PROTECTION**

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.010 **PIPING SCHEDULE**

A. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings, hubless-piping couplings.
   3. Copper Type DWV tube, copper drainage fittings, and soldered joints.

B. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings, hubless-piping couplings.
   3. Copper Type DWV tube, copper drainage fittings, and soldered joints.

C. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings, hubless-piping couplings.
   3. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Underground, soil, waste, and vent branch piping NPS 4 and smaller servicing drains for boilers and water heaters shall be the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings, hubless-piping couplings.

**END OF SECTION**
SECTION 22 1319
SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Backwater valves.
2. Cleanouts.
3. Roof flashing assemblies.

1.02 DEFINITIONS

A. PVC: Polyvinyl chloride

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.02 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:
2. Size: Same as connected piping.
4. Cover: Cast iron with bolted or threaded access check valve.
5. End Connections: Hub and spigot or Hub and spigot or hubless or Hubless.
6. Type Check Valve: Removable, bronze, swing check, factory assembled, or field modified to hang closed or open for airflow unless subject to backflow condition.
7. Extension: ASTM A74, Service Class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Horizontal, Plastic Backwater Valves:
1. Size: Same as connected piping.
2. Body: PVC.
3. Cover: Same material as body with threaded access to check valve.
4. Check Valve: Removable swing check.
5. End Connections: Socket type.

2.03 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:
1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk or Countersunk or raised-headar plastic plug.
B. Cast-Iron Exposed Floor Cleanouts:
   1. Standard: ASME A112.36.2M
   2. Riser: ASTM A74.
C. Cast-Iron Wall Cleanouts:
   1. Standard: ASME A112.36.2M. Include wall access.
   2. Size: Same as connected drainage piping.
   3. Body: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
   4. Closure Plug:
      a. Brass.
      b. Countersunk head.
      c. Drilled and threaded for cover attachment screw.
      d. Size: Same as or not more than one size smaller than cleanout size.
   5. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

2.04 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
   1. Description: Manufactured assembly made of 6.0-lb/sq. ft, lead flashing collar and skirt extending at least 6 inches or 8 inches or 10 inches from pipe, with galvanized-steel boot reinforcement and counterflash fitting.
      b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
      c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.05 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A74, 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 C564 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 spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.
D. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.
E. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:
1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install backwater valves in building drain piping.
1. 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.

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 flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

G. Install deep-seal traps on floor drains and other waste outlets, if indicated.

H. 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.

I. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

J. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

K. Install vent caps on each vent pipe passing through roof.

L. Install wood-blocking reinforcement for wall-mounting-type specialties.

M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
3.02 PIPING CONNECTIONS
A. 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.
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.
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. 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.

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.

END OF SECTION
SECTION 22 1413
FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
2. Hubless, cast-iron soil pipe and fittings.
3. Specialty pipe and fittings.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 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.

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

A. Pipe and Fittings:
1. Marked with CISPI collective trademark and NSF certification mark.
2. Class: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

2.03 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:
1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
1. Couplings shall bear CISPI collective trademark and NSF certification mark.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:
2. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
D. Cast-Iron, Hubless-Piping Couplings:
   2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.04 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
   3. Unshielded, Nonpressure Transition Couplings:
      b. Description: Elastomeric sleeve, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
      c. Sleeve Materials:
         2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
         3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
   4. Shielded, Nonpressure Transition Couplings:
      b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
      c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping.
K. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
   1. Do not change direction of flow more than 90 degrees.
   2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
      a. Reducing size of drainage piping in direction of flow is prohibited.

L. Lay buried building piping beginning at low point of each system.
   1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
   2. Install required gaskets according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements.
   3. Maintain swab in piping and pull past each joint as completed.

M. Install piping at the following minimum slopes unless otherwise indicated:
   1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.

N. Install cast-iron soil piping according to CISPI’s "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Plumbing Specialties:
   1. Install backwater valves in storm drainage gravity-flow piping.
   2. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
   3. Install drains in storm drainage gravity-flow piping.

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

Q. Install sleeves for piping penetrations of walls, ceilings, and floors.

R. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

3.03 JOINT CONSTRUCTION


B. Hubless, Cast-Iron Soil Piping Coupled Joints:

C. PVC, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendices.
   3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendices.

D. Joint Restraints and Sway Bracing:
   1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
      a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
      b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.
      c. Provide rigid sway bracing for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction and branch openings.
3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: Unshielded or Shielded, nonpressure transition couplings.

3.05 VALVE INSTALLATION

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

B. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

C. 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. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

3.06 INSTALLATION OF HANGERS AND SUPPORTS

A. Support piping and tubing not listed above according to MSS SP-58 and manufacturer’s written instructions.

3.07 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.

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

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

3.08 IDENTIFICATION

A. Identify exposed storm drainage piping.

3.09 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Performed tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
B. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
      a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   3. Test Procedure:
      a. Test storm drainage piping on completion of roughing-in.
      b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.

C. Piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.010 CLEANING AND PROTECTION
A. Clean interior of piping. Remove dirt and debris as work progresses.
B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.011 PIPING SCHEDULE
A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
B. Above & below ground storm drainage piping NPS 8 and smallershall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Miscellaneous storm drainage piping specialties.
   2. Cleanouts.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.01 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES
A. Downspout Adaptors:
   1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
   2. Size: Inlet size to match parapet drain outlet.
B. Downspout Boots:
   1. Description: Manufactured, ASTM A48/A48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
   2. Size: Inlet size to match downspout and NPS 4 outlet.

2.02 CLEANOUTS
A. Cast-Iron Exposed Cleanouts:
   1. Standard: ASME A112.36.2M.
   2. Size: Same as connected branch.
   3. Body Material: [Hub-and-spigot, cast-iron soil pipe T-branch] [No-hub, cast-iron soil pipe test tee] as required to match connected piping.
   4. Closure: Countersunk, brass or cast-iron plug.
   5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.
B. Cast-Iron Wall Cleanouts:
   1. Standard: ASME A112.36.2M. Include wall access.
   2. Size: Same as connected drainage piping.
   3. Body: [Hub-and-spigot, cast-iron soil pipe T-branch] [No-hub, cast-iron soil pipe test tee] as required to match connected piping.
   4. Closure Plug:
      a. Brass.
      b. Countersunk head.
      c. Drilled and threaded for cover attachment screw.
      d. Size: Same as, or not more than, one size smaller than cleanout size.
C. Test Tees:
   1. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
      1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
      2. Install expansion joints, if indicated, in roof drain outlets.
      3. Position roof drains for easy access and maintenance.
   B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
   C. Install downspout boots at grade with top [6 inches] [12 inches] [18 inches] above grade. Secure to building wall.
   D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
   E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
      1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
      2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
      3. Locate cleanouts at minimum intervals of [50 feet] for piping NPS 4 and smaller and 100 feet for larger piping.
      4. Locate cleanouts at base of each vertical storm piping conductor.
   F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
   G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
   H. Install test tees in vertical conductors and near floor.
   I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
   J. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

3.02 FLASHING INSTALLATION
   A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.
   B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   C. Set flashing on floors and roofs in solid coating of bituminous cement.
   D. Secure flashing into sleeve and specialty clamping ring or device.

3.03 PROTECTION
   A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
SECTION 22 3400

FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Commercial, direct-vent, gas-fired, storage, domestic-water heater.
   2. Domestic-water heater accessories.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale and coordinated with all building trades.
B. Seismic Qualification Data: Certificates, for fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.
C. Product Certificates: For each type of commercial, gas-fired domestic-water heater.
D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
E. Source quality-control reports.
F. Field quality-control reports.
G. Sample warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 COORDINATION

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

PART 2 - PRODUCTS

2.01 DOMESTIC-WATER HEATER ACCESSORIES

A. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.
B. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.
C. Heat-Trap Fittings: ASHRAE 90.2.
D. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves.
   1. Comply with requirements for balancing valves.
F. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3
H. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
I. Pressure Relief Valves: Include pressure setting less than working-pressure rating of domestic-water heater.
K. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.02 SOURCE QUALITY CONTROL
A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.
C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 DOMESTIC-WATER HEATER INSTALLATION
A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
   1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
   2. Maintain manufacturer's recommended clearances.
   3. Arrange units so controls and devices that require servicing are accessible.
   4. 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 concrete base.
   5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   7. Install anchor bolts to elevations required for proper attachment to supported equipment.
   8. Anchor domestic-water heaters to substrate.
B. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
   1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
C. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
   1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves.

D. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices.

E. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-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.

F. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-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.

G. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains.

H. Install thermometer on outlet piping of domestic-water heaters.

I. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet.

J. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

K. Fill domestic-water heaters with water.

L. Charge domestic-water expansion tanks with air to required system pressure.

M. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

N. Identify system components.

3.02 PIPING CONNECTIONS

A. Comply with requirements for domestic-water piping.

B. Comply with requirements for gas piping.

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

D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.03 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.
D. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION
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 alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.02 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 NEMA MG 1 unless otherwise indicated.

2.02 MOTOR CHARACTERISTICS

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

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

2.03 POLYPHASE MOTORS

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

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

C. Service Factor: 1.15.

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


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 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

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

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

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 Applicable)

END OF SECTION
SECTION 23 0529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.04 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
C. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.

2.02 TRAPEZE PIPE HANGERS

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

A. Insulation-Insert Material for Cold Piping: [ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: [Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi] [ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

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

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

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

2.04 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.05 EQUIPMENT SUPPORTS

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

2.06 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, 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 APPLICATION

A. Comply with requirements for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.02 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. [Metal] [Fiberglass] Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

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

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

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

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


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

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

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

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

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

O. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 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 bearing surface smooth.

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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

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

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

3.06 PAINTING

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

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.
3.07 HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

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

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

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

F. Use [stainless-steel pipe hangers] [and] [fiberglass pipe hangers] [and] [fiberglass strut systems] and [stainless-steel] [or] [corrosion-resistant] attachments for hostile environment applications.

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, 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 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.

11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.

12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

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

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

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

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

   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
      a. Light (MSS Type 31): 750 lb.
      b. Medium (MSS Type 32): 1500 lb.
      c. Heavy (MSS Type 33): 3000 lb.
  13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
  15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
   3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
   6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
   7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
   8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: [Brass, 0.032-inch] [stainless steel, 0.025-inch] [aluminum, 0.032-inch] [or] [anodized aluminum, 0.032-inch] minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.
3. Background Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. 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-quarters the size of principal lettering.
6. Fasteners: Stainless-steel [rivets] [or] [self-tapping screws].
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch] [1/8 inch] thick, and having predrilled holes for attachment hardware.
2. Letter Color: [Black] [Blue] [Red] [White] [Yellow].
3. Background Color: [Black] [Blue] [Red] [White] [Yellow].
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel [rivets] [or] [self-tapping screws].
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch] [1/8 inch] thick and having predrilled holes for attachment hardware.

B. Letter Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.

C. Background Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.

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-quarters 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 according to ASME A13.1.

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

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: [Size letters according to ASME A13.1 for piping] [At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances].

2.04 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch] [1/8 inch] thick and having predrilled holes for attachment hardware.

B. Letter Color: [Black] [Blue] [Red] [White] [Yellow].

C. Background Color: [Black] [Blue] [Red] [White] [Yellow].

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters 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. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surface 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. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule:
   1. Chilled-Water Piping: [White letters on a safety-green background] [Black letters on a safety-orange background]
   2. Condenser-Water Piping: [White letters on a safety-green background] [Black letters on a safety-orange background]
   3. Heating Water Piping: [White letters on a safety-green background] [Black letters on a safety-orange background]
   4. Refrigerant Piping: [Black letters on a safety-orange background] [White letters on a safety-purpale background] [Black letters on a safety-white background] [White letters on a safety-gray background] [White letters on a safety-black background]
   5. Low-Pressure Steam Piping: [White letters on a safety-purpale background] [Black letters on a safety-white background] [White letters on a safety-gray background] [White letters on a safety-black background]
   6. High-Pressure Steam Piping: [White letters on a safety-purpale background] [Black letters on a safety-white background] [White letters on a safety-gray background] [White letters on a safety-black background]
   7. Steam Condensate Piping: [White letters on a safety-purpale background] [Black letters on a safety-white background] [White letters on a safety-gray background] [White letters on a safety-black background]
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.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION
SECTION 23 0593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.

1.02 DEFINITIONS
C. TAB: Testing, adjusting, and balancing.
D. TABB: Testing, Adjusting, and Balancing Bureau.
E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
F. TDH: Total dynamic head.

1.03 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.04 INFORMATIONAL SUBMITTALS
B. Certified TAB reports.

1.05 QUALITY ASSURANCE
A. TAB Specialists Qualifications: Certified by AABC.
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
B. TAB Specialists Qualifications: Certified by NEBB or TABB.
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
   2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.
C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
PART 2 - PRODUCTS (Not Applicable)

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.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures for balancing the systems.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Airside:
      a. Duct systems are complete with terminals installed.
      b. Volume, smoke, and fire dampers are open and functional.
      c. Clean filters are installed.
      d. Fans are operating, free of vibration, and rotating in correct direction.
      e. Variable-frequency controllers' startup is complete and safeties are verified.
      f. Automatic temperature-control systems are operational.
      g. Ceilings are installed.
      h. Windows and doors are installed.
      i. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB’s "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA’s "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
   2. After testing and balancing, install test ports and duct access doors.
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems’ "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.
K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
      a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
      b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.
      c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   2. Measure fan static pressures as follows:
      a. Measure static pressure directly at the fan outlet or through the flexible connection.
      b. Measure static pressure directly at the fan inlet or through the flexible connection.
      c. Measure static pressure across each component that makes up the air-handling system.
      d. Report artificial loading of filters at the time static pressures are measured.
   3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
   4. Obtain approval from Architector commissioning authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
   5. 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
   1. Measure airflow of submain and branch ducts.
   2. Adjust submain and branch duct volume dampers for specified airflow.
   3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
   1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
   2. Measure inlets and outlets airflow.
   3. Adjust each inlet and outlet for specified airflow.
   4. Re-measure each inlet and outlet after they have been adjusted.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:
   1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
   2. Verify that the system is under static pressure control.
   3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
      a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
      b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
d. Adjust controls so that terminal is calling for minimum airflow.
e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record
calibration factor. If no minimum calibration is available, note any deviation from design
airflow.
f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck
airstreams unless so designed.
g. On constant volume terminals, in critical areas where room pressure is to be maintained,
verify that the airflow remains constant over the full range of full cooling to full heating. Note
any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust
fans to deliver total design airflows within the maximum allowable fan speed listed by fan
manufacturer.
a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum
outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for
maximum and minimum airflow so that connected total matches fan selection and simulates
actual load in the building.
c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform
multiple Pitot-tube traverses to obtain total airflow.
d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse
may be acceptable.
e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals
and calculate the total airflow.

6. Measure fan static pressures as follows:
a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and
minimum outdoor airflow.
a. Balance the return-air ducts and inlets the same as described for constant-volume air
systems.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static
pressure set point to the most energy-efficient set point to maintain the optimum system static
pressure. Record set point and give to controls contractor.

9. Verify final system conditions as follows:
a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design.
Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure
and record all operating data.
f. Verify tracking between supply and return fans.

3.07 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.
A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report’s binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Fan curves.
   2. Manufacturers’ test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   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 supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:
       a. Indicated versus final performance.
       b. Notable characteristics of systems.
       c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer’s name, type, size, and fittings.
   14. Notes to explain why certain final data in the body of reports vary from indicated values.
   15. Test conditions for fans and pump performance forms including the following:
       a. Settings for outdoor-, return-, and exhaust-air dampers.
       b. Conditions of filters.
       c. Cooling coil, wet- and dry-bulb conditions.
       d. Face and bypass damper settings at coils.
       e. Fan drive settings including settings and percentage of maximum pitch diameter.
       f. Inlet vane settings for variable-air-volume systems.
       g. Settings for supply-air, static-pressure controller.
       h. Other system operating conditions that affect performance.

D. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer’s serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches, and bore.
      i. Center-to-center dimensions of sheave and amount of adjustments in inches.
      j. Number, make, and size of belts.
      k. Number, type, and size of filters.
   2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

E. Apparatus-Coil Test Reports:
   1. Coil Data:
      a. System identification.
      b. Location.
      c. Coil type.
      d. Number of rows.
      e. Fin spacing in fins per inch o.c.
      f. Make and model number.
      g. Face area in sq. ft.
      h. Tube size in NPS.
      i. Tube and fin materials.
      j. Circuiting arrangement.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Average face velocity in fpm.
      c. Air pressure drop in inches wg.
      d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
      e. Return-air, wet- and dry-bulb temperatures in deg F.
      f. Entering-air, wet- and dry-bulb temperatures in deg F.
      g. Leaving-air, wet- and dry-bulb temperatures in deg F.
      h. Water flow rate in gpm.
      i. Water pressure differential in feet of head or psig.
      j. Entering-water temperature in deg F.
      k. Leaving-water temperature in deg F.
      l. Refrigerant expansion valve and refrigerant types.
      m. Refrigerant suction pressure in psig.
      n. Refrigerant suction temperature in deg F.
      o. Inlet steam pressure in psig.

F. Gas-Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
   1. Unit Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Fuel type in input data.
g. Output capacity in Btu/h.

h. Ignition type.

i. Burner-control types.

j. Motor horsepower and rpm.

k. Motor volts, phase, and hertz.

l. Motor full-load amperage and service factor.

m. Sheave make, size in inches, and bore.

n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Entering-air temperature in deg F.
   c. Leaving-air temperature in deg F.
   d. Air temperature differential in deg F.
   e. Entering-air static pressure in inches wg.
   f. Leaving-air static pressure in inches wg.
   g. Air static-pressure differential in inches wg.
   h. Low-fire fuel input in Btu/h.
   i. High-fire fuel input in Btu/h.
   j. Manifold pressure in psig.
   k. High-temperature-limit setting in deg F.
   l. Operating set point in Btu/h.
   m. Motor voltage at each connection.
   n. Motor amperage for each phase.
   o. Heating value of fuel in Btu/h.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
   1. Unit Data:
      a. System identification.
      b. Location.
      c. Coil identification.
      d. Capacity in Btu/h.
      e. Number of stages.
      f. Connected volts, phase, and hertz.
      g. Rated amperage.
      h. Airflow rate in cfm.
      i. Face area in sq. ft..
      j. Minimum face velocity in fpm.
   2. Test Data (Indicated and Actual Values):
      a. Heat output in Btu/h.
      b. Airflow rate in cfm.
      c. Air velocity in fpm.
      d. Entering-air temperature in deg F.
      e. Leaving-air temperature in deg F.
      f. Voltage at each connection.
      g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches, and bore.
      h. Center-to-center dimensions of sheave and amount of adjustments in inches.
   2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling-unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F.
      d. Duct static pressure in inches wg.
      e. Duct size in inches.
      f. Duct area in sq. ft..
      g. Indicated airflow rate in cfm.
      h. Indicated velocity in fpm.
      i. Actual airflow rate in cfm.
      j. Actual average velocity in fpm.
      k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Apparatus used for test.
      d. Area served.
      e. Make.
      f. Number from system diagram.
      g. Type and model number.
      h. Size.
      i. Effective area in sq. ft..
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Air velocity in fpm.
      c. Preliminary airflow rate as needed in cfm.
      d. Preliminary velocity as needed in fpm.
      e. Final airflow rate in cfm.
      f. Final velocity in fpm.
      g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
   1. Unit Data:
      a. System and air-handling-unit identification.
      b. Location and zone.
      c. Room or riser served.
      d. Coil make and size.
      e. Flowmeter type.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

L. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.09 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect or commissioning authority.

B. Architect or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:
   1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
   3. If the second verification also fails, Owner or Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.010 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION
SECTION 23 0713
DUCT INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
   6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
   7. Indoor, concealed oven and warewash exhaust.
   8. Indoor, exposed oven and warewash exhaust.
   9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
  11. Outdoor, concealed supply and return.
  12. Outdoor, exposed supply and return.

1.02 ACTION SUBMITTALS

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

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

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS


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 C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, [Type I] [Type II with factory-applied vinyl jacket] [Type III with factory-applied FSK jacket] [Type III with factory-applied FSP jacket]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation [without factory-applied jacket] [with factory-applied ASJ] [with factory-applied FSK jacket]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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 [1] [2]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.03 ADHESIVES

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

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


D. PVC Jacket Adhesive: Compatible with PVC jacket.

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
   1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.

2.05 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
2.06 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 C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
   4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
   5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.07 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. in., in a Leno weave, for ducts.

2.08 FIELD-APPLIED JACKETS
A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: [White] [Color-code jackets based on system. Color as selected by Architect].
D. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. [Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size].
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: [1-mil- thick, heat-bonded polyethylene and kraft paper] [3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick polysurlyn].
   4. Moisture Barrier for Outdoor Applications: [3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick polysurlyn].
E. 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 crosslaminated polyethylene film covered with [white] [stucco-embossed] aluminum-foil facing.

2.09 TAPES
A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. 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 C1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.010 SECUREMENTS

A. Aluminum Bands: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, [1/2 inch] [3/4 inch] wide with [wing seal] [or] [closed seal].

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. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
   b. Spindle: [Copper- or zinc-coated, low-carbon steel] [Aluminum] [Stainless steel], fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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. Baseplate: Perforated, nylon sheet, 0.030-inch-thick by 1-1/2 inches in diameter.
   b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   c. 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. Baseplate: Galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
   b. Spindle: [Copper- or zinc-coated, low-carbon steel] [Aluminum] [Stainless steel], fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, [galvanized-steel] [aluminum] [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. 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.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
D. Wire: [0.080-inch nickel-copper alloy] [0.062-inch soft-annealed, stainless steel] [0.062-inch soft-annealed, galvanized steel].

2.011 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, 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 B209, 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.

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 ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches] [4 inches] o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer’s written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.03 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 Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

E. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies.

3.04 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not overcompress insulation during installation.
      e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not 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 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
3.05 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 PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.06 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.

3.07 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below.
   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.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.09 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. 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.

3.010 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

D. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

E. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

F. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

G. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

H. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

I. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

J. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

3.011 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

C. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.
D. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

F. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber [blanket] [board], [1-1/2 inches] [2 inches] [3 inches] thick and [0.75-lb/cu. ft.] [1.5-lb/cu. ft.] [3-lb/cu. ft.] nominal density.

3.012 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.
   2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
   3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch] [0.020 inch] [0.024 inch] [0.032 inch] [0.040 inch] thick.

D. Ducts and Plenums, Exposed:
   1. None.
   2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
   3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch] [0.020 inch] [0.024 inch] [0.032 inch] [0.040 inch] thick.

3.013 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:
   1. None.
   2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
   3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch] [0.020 inch] [0.024 inch] [0.032 inch] [0.040 inch] thick.

D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch] [0.020 inch] [0.024 inch] [0.032 inch] [0.040 inch] thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. [Painted] Aluminum, [Smooth] [Stucco Embossed] with [1-1/4-Inch-Deep Corrugations] [2-1/2-Inch-Deep Corrugations] [4-by-1-Inch Box Ribs]: [0.032 inch] [0.040 inch] thick.

END OF SECTION
SECTION 23 0800
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.01 SUMMARY
A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

1.02 DEFINITIONS
A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
B. CxA: Commissioning Authority.
D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.03 INFORMATIONAL SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Certificates of readiness.
C. Certificates of completion of installation, prestart, and startup activities.

1.04 ALLOWANCES
A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Section 012100 "Allowances."

1.05 UNIT PRICES
A. Commissioning testing allowance may be adjusted up or down when actual man-hours are computed at the end of commissioning testing.

1.06 CONTRACTOR'S RESPONSIBILITIES
A. Perform commissioning tests at the direction of the CxA.
B. Attend construction phase controls coordination meeting.
C. Attend testing, adjusting, and balancing review and coordination meeting.
D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
E. Provide information requested by the CxA for final commissioning documentation.
F. Provide measuring instruments and logging devices to record test data and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.07 CxA'S RESPONSIBILITIES
A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
B. Direct commissioning testing.
C. Verify testing, adjusting, and balancing of Work are complete.

1.08 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:
   1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
   2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
   3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
   4. Certificate of readiness, signed by the Contractor, certifying that HVAC&R systems, assemblies, equipment, components, and associated controls are ready for testing.
   5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
   6. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
   7. Test and inspection reports and certificates.
   8. Corrective action documents.
   9. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.01 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
E. Inspect and verify the position of each device and interlock identified on checklists.
F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.02 Testing AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
B. Notify the CxA at least 10 days in advance of testing and balancing Work and provide access for the CxA to witness testing and balancing Work.
C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the
direction of the CxA.

1. The CxA will notify testing and balancing Contractor or Subcontractor 10 days in advance of the
date of field verification. Notice will not include data points to be verified.

2. The testing and balancing Contractor or Subcontractor shall use the same instruments (by model
and serial number) that were used when original data were collected.

3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more
than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing
report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing.
Variations in background noise must be considered.

4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.03 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat
generation and refrigeration through distribution systems to each conditioned space. Testing shall
include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency
conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor or Subcontractor, testing and balancing Contractor or
Subcontractor, and HVAC&R Instrumentation and Control Contractor or Subcontractor shall prepare
detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under
design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to
simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and
methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating
conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system,
document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and
documentation and schedule seasonal tests.

3.04 HVAC&R systems, subsystems, and equipment Testing Procedures

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections.
Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are
specified. Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in
HVAC piping Sections. HVAC&R Contractor or Subcontractor shall prepare a pipe system cleaning,
flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final
reports to the CxA. Plan shall include the following:
1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

2. Description of equipment for flushing operations.


4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas and solar systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. DDC system for monitoring and controlling of HVAC systems.
   2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

1.02 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:
   2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
   3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
   5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. LAN: Local area network.

O. LNS: LonWorks Network Services.

P. LON Specific Definitions:
1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.
13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTS create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTS are not allowed.

Q. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

R. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

S. Modbus TCP/IP: An open protocol for exchange of process data.
T. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

U. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

V. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

W. Peer to Peer: Networking architecture that treats all network stations as equal partners.

X. POT: Portable operator's terminal.

Y. RAM: Random access memory.

Z. RF: Radio frequency.

AA. Router: Device connecting two or more networks at network layer.

BB. TCP/IP: Transport control protocol/Internet protocol.

CC. UPS: Uninterruptible power supply.

DD. USB: Universal Serial Bus.

EE. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

FF. VAV: Variable air volume.

GG. WLED: White light emitting diode.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site <Insert location>.

1.04 ACTION SUBMITTALS

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

B. Product Data: For each type of product include the following:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   4. Installation, operation and maintenance instructions including factors effecting performance.
   5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
      a. Workstations.
      b. Servers.
      c. Printers.
      d. Gateways.
      e. Routers.
      f. Protocol analyzers.
      g. DDC controllers.
      h. Enclosures.
      i. Electrical power devices.
j. UPS units.
k. Accessories.
l. Instruments.
m. Control dampers and actuators.
n. Control valves and actuators.

6. When manufacturer’s product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:
1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:
1. Include plans, elevations, sections, and mounting details where applicable.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail means of vibration isolation and show attachments to rotating equipment.
4. Plan Drawings indicating the following:
   a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
   d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
   e. Network communication cable and raceway routing.
   f. Information, drawn to scale, of <Insert requirements>.
   g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
5. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

6. Control panel drawings indicating the following:
a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
c. Front, rear, and side elevations and nameplate legend.
d. Unique drawing for each panel.

7. DDC system network riser diagram indicating the following:
a. Each device connected to network with unique identification for each.
b. Interconnection of each different network in DDC system.
c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

8. DDC system electrical power riser diagram indicating the following:
a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

9. Monitoring and control signal diagrams indicating the following:
a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches and transmitters.
d. Process signal tubing to sensors, switches and transmitters.

10. Color graphics indicating the following:
a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
c. Intended operator access between related hierarchical display screens.

E. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outputs.
d. Operator workstation failure.
e. Gateway failure.
f. Network failure
g. Controller failure.
h. Instrument failure.
i. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

F. Samples:
1. For each exposed product, installed in finished space for approval of selection of aesthetic characteristics.

G. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.
1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Face velocity at Project design and minimum airflow conditions.
   c. Pressure drop across damper at Project design and minimum airflow conditions.
   d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
   e. Maximum close-off pressure.
   f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.
3. Schedule and design calculations for control valves and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure-differential drop across valve at Project design flow condition.
   c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
   d. Design and minimum control valve coefficient with corresponding valve position.
   e. Maximum close-off pressure.
   f. Leakage flow at maximum system pressure differential.
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.
4. Schedule and design calculations for selecting flow instruments.
   a. Instrument flow range.
   b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
   c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
   d. Pressure-differential loss across instrument at Project design flow conditions.
   e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings, reflected ceiling plan(s), and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Qualification Data:
1. Systems Provider Qualification Data:
   a. Resume of project manager assigned to Project.
   b. Resumes of application engineering staff assigned to Project.
   c. Resumes of installation and programming technicians assigned to Project.
d. Resumes of service technicians assigned to Project.
e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
h. Owner contact information for past project including name, phone number, and e-mail address.
i. Contractor contact information for past project including name, phone number, and e-mail address.
j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.

2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

C. Welding certificates.

D. Product Certificates:
   1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
   2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

E. Product Test Reports: For each product that requires testing to be performed by [manufacturer] [manufacturer and witnessed by a qualified testing agency] [a qualified testing agency].

F. Preconstruction Test Reports: For each separate test performed.

G. Source quality-control reports.

H. Field quality-control reports.

I. Sample Warranty: For manufacturer's warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
   1. Include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
      e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
      h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers’ recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.

C. Furnish parts, as indicated by manufacturer’s recommended parts list, for product operation during [one] [two]-year period following warranty period.

D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:
   1. Network Controller: One.
   2. Programmable Application Controller: One.
   3. Application-Specific Controller: One.
   4. Room Carbon Dioxide Sensor and Transmitter: One.
   5. Room Moisture Sensor and Transmitter: One.
   6. Room Pressure Sensor and Transmitter: One.
   7. Room Temperature Sensor and Transmitter: One.
   14. DC Power Supply: One.
   15. Supply of 20 percent spare optical fiber cable splice organizer cabinets for several re-terminations.

1.08 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:
   1. Nationally recognized manufacturer of DDC systems and products.
   2. DDC systems with similar requirements to those indicated for a continuous period of [five] [10] years within time of bid.
   3. DDC systems and products that have been successfully tested and in use on at least [three] [five] past projects.
   4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
   5. Having full-time in-house employees for the following:
      a. Product research and development.
      b. Product and application engineering.
      c. Product manufacturing, testing and quality control.
      d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
      e. Owner operator training.
B. DDC System Provider Qualifications:
1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within <Insert distance> of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within [three] [five] consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of Work if necessary, to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

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

1.09 PRECONSTRUCTION TESTING
A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on field mockups.
1. Include test assemblies representative of proposed materials and construction.
2. Build mockup at testing agency facility using personnel, materials, and methods of construction that will be used at Project site.
3. Notify Architect seven days in advance of dates and times of tests.

B. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.

PART 2 - PRODUCTS

2.01 DDC SYSTEM MANUFACTURERS

2.02 DDC SYSTEM DESCRIPTION
A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

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

2.03 WEB ACCESS
A. DDC system shall be web based or web compatible.
1. Web-Based Access to DDC System:
a. DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.

b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.

c. web access shall be password protected.

2. Web-Compatible Access to DDC System:

   a. Workstation and or server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

   b. DDC system shall support web browser access to building data. Operator using a standard web browser shall be able to access control graphics and change adjustable set points.

   c. Web access shall be password protected.

2.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

   1. System Performance Objectives:
      a. DDC system shall manage HVAC systems.
      b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
      c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
      d. DDC system shall operate while unattended by an operator and through operator interaction.
      e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:

   1. Response Time of Connected I/O:
      a. AI point values connected to DDC system shall be updated at least every [five] [two] seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      b. BI point values connected to DDC system shall be updated at least every [five] [two] seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      c. AO points connected to DDC system shall begin to respond to controller output commands within [two] [one] second(s). Global commands shall also comply with this requirement.
      d. BO point values connected to DDC system shall respond to controller output commands within [two] [one] second(s). Global commands shall also comply with this requirement.

   2. Display of Connected I/O:
      a. Analog point COV connected to DDC system shall be updated and displayed at least every [10] [five] seconds for use by operator.
      b. Binary point COV connected to DDC system shall be updated and displayed at least every [10] [five] seconds for use by operator.
      c. Alarms of analog and digital points connected to DDC system shall be displayed within [45] [30] [15] seconds of activation or change of state.
      d. Graphic display refresh shall update within [eight] [four] seconds.
      e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
D. Network Bandwidth: Design each network of DDC system to include at least [30] percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. DDC System Data Storage:
1. Include capability to archive not less than [24] [48] [60] consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage:
   a. Provide [server] [workstation] with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in “DDC Data Access” Paragraph.
3. Cloud Storage:
   a. Provide [application-based] [and] [web browser] interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in “DDC Data Access” Paragraph.

F. DDC Data Access:
1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

G. Future Expandability:
1. DDC system size shall be expandable to an ultimate capacity of at least [two] [three] [four] times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

H. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Energy:
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.
2. Flow:
3. Gas:
   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
   c. Oxygen: Within 5 percent of reading.
   d. Refrigerant: Within 50 ppm.
4. Moisture (Relative Humidity):
6. Pressure:
   a. Air, Ducts and Equipment: [1] [0.5] percent of instrument [range] [span].
   b. Space: Within [1] [0.5] [0.25] percent of instrument [range] [span].
   c. Water: Within [1] [0.5] [0.25] percent of instrument [range] [span].
7. Speed: Within [10%] [5%] percent of reading.

8. Temperature, Dew Point:
   a. Air: Within [1 deg F] [0.5 deg F].
   b. Space: Within [1 deg F] [0.5 deg F].
   c. Outdoor: Within [3 deg F] [2 deg F].

9. Temperature, Dry Bulb:
   a. Air: Within [1 deg F] [0.5 deg F].
   b. Space: Within [1 deg F] [0.5 deg F].
   c. Outdoor: Within [2 deg F] [1 deg F].
   d. Temperature Difference: Within [0.25 deg F].
   e. Other Temperatures Not Indicated: Within [1 deg F] [0.5 deg F].

10. Temperature, Wet Bulb:
    a. Air: Within [1 deg F] [0.5 deg F].
    b. Space: Within [1 deg F] [0.5 deg F].
    c. Outdoor: Within [2 deg F] [1 deg F].


I. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:
   a. Milliamperes: Nearest 1/100th of a milliampere.
   b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:
   a. Electric Power:
      1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
      2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
      3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
   b. Thermal, Rate:
      1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
      2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
   c. Thermal, Usage:
      1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
      2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 ton-hours above 10,000 ton-hours.

3. Flow:
   a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
   b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

4. Gas:
   c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
   d. Refrigerant (ppm): Nearest ppm.

5. Moisture (Relative Humidity):
   a. Relative Humidity (Percentage): Nearest 1 percent.

6. Level: Nearest 1/100th of an inch through 10 inches, nearest 1/10 of an inch between 10 and 100 inches, nearest inch above 100 inches.

7. Speed:
a. Rotation (rpm): Nearest 1 rpm.
b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
9. Pressure:
   a. Air, Ducts and Equipment: Nearest 1/10th in. w.c..
   b. Space: Nearest 1/100th in. w.c. .
   c. Steam: Nearest 1/10th psig through 100 psig, nearest psig above 100 psig.
   d. Water: Nearest 1/10 psig through 100 psig, nearest psig above 100 psig.
10. Temperature:
    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest degree.
    c. Space: Nearest 1/10th of a degree.
11. Vibration: Nearest 1/10th in/s.
12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

J. Control Stability: Control variables indicated within the following limits:
1. Flow:
2. Gas:
   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
   c. Oxygen: Within 5 percent of reading.
3. Moisture (Relative Humidity):
5. Pressure:
   a. Air, Ducts and Equipment: [1] [0.5] percent of instrument [range] [span].
   b. Space: Within [1] [0.5] [0.25] percent of instrument [range] [span].
   c. Water: Within [1] [0.5] [0.25] percent of instrument [range] [span].
6. Temperature, Dew Point:
   a. Air: Within [1 deg F] [0.5 deg F].
   b. Space: Within [1 deg F] [0.5 deg F].
7. Temperature, Dry Bulb:
   a. Air: Within [2 deg F] [1 deg F] [0.5 deg F].
   b. Space: Within [2 deg F] [1 deg F] [0.5 deg F] .
8. Temperature, Wet Bulb:
   a. Air: Within [1 deg F] [0.5 deg F].
   b. Space: Within [1 deg F] [0.5 deg F].

K. Environmental Conditions for Controllers, Gateways, and Routers:
1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures.
   a. Outdoors, Protected: [Type 2] [Type 3] [Type 12].
   b. Outdoors, Unprotected: [Type 4] [Type 4X].
   c. Indoors, Heated with Filtered Ventilation: [Type 1] [Type 2].
d. Indoors, Heated with Non-Filtered Ventilation: [Type 2] [Type 12].

e. Indoors, Heated and Air Conditioned: [Type 1].

f. Mechanical Equipment Rooms:
   1) Chiller and Boiler Rooms: [Type 12] [Type 4] [Type 4X].
   2) Air-Moving Equipment Rooms: [Type 1] [Type 2] [Type 12].

g. Localized Areas Exposed to Washdown: [Type 4] [Type 4X].

h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation:
   [Type 2] [Type 3] [Type 12].

i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation:
   [Type 4] [Type 4X].


L. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
   a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: [Type 2] [Type 3] [Type 12].
   b. Outdoors, Unprotected: [Type 4] [Type 4X].
   c. Indoors, Heated with Filtered Ventilation: [Type 1] [Type 2].
   d. Indoors, Heated with Non-Filtered Ventilation: [Type 2] [Type 12].
   e. Indoors, Heated and Air-conditioned: Type 1.
   f. Mechanical Equipment Rooms:
      1) Chiller and Boiler Rooms: [Type 12] [Type 4] [Type 4X].
      2) Air-Moving Equipment Rooms: [Type 1] [Type 2] [Type 12].

g. Localized Areas Exposed to Washdown: [Type 4] [Type 4X].

h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation:
   [Type 2] [Type 3] [Type 12].

i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation:
   [Type 4] [Type 4X].


M. Electric Power Quality:

1. Power-Line Surges:
   a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
   b. Do not use fuses for surge protection.
   c. Test protection in the normal mode and in the common mode, using the following two waveforms:
      1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
      2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:
   a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
      1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

N. Backup Power Source:
1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

O. UPS:
1. DDC system products powered by UPS units shall include the following:
   a. Desktop workstations.
   b. Printers.
   c. Servers.
   d. Gateways.
   e. DDC controllers, except application-specific controllers.
2. DDC system instruments and actuators powered by UPS units shall include the following:
   a. Instruments associated with the following systems controlled by DDC system:
   b. Dampers and actuators associated with the following systems controlled by DDC system:
   c. Valves and actuators associated with the following systems controlled by DDC system.

P. Continuity of Operation after Electric Power Interruption:
1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.05 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than [two] [or] [three] levels of LANs.
1. Level one LAN shall connect network controllers and operator workstations.
2. [Level one] [or] [Level two] LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. [Level two] [or] [Level three] LAN shall connect application-specific controllers to programmable application controllers and network controllers.
4. [Level two] [or] [Level three] LAN shall connect application-specific controllers to application-specific controllers.

B. Minimum Data Transfer and Communication Speed:
1. LAN Connecting Operator Workstations and Network Controllers: [100] [10] [2.5] [1.25] Mbps.
2. LAN Connecting Programmable Application Controllers: [1000] [100] kbps.
3. LAN Connecting Application-Specific Controllers: [115,000] [76,800] [38,400] [19,200] bps.

C. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than [two] [three] times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

H. Special Network Architecture Requirements:
   1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.06 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
   1. Desktop and portable workstation with hardwired connection through LAN port.
   2. Portable operator terminal with hardwired connection through LAN port.
   3. Portable operator workstation with wireless connection through LAN router.
   4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
   5. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
   1. Each mechanical equipment room.
   2. Each boiler room.
   3. Each chiller room or outdoor chiller yard.
   4. Each cooling tower location.
   5. Each different roof level with roof-mounted air-handling units or rooftop units.
   7. Fire-alarm system command center.

D. Desktop Workstations:
   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:
   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on a DDC system LAN.
   3. Connect to DDC system [Level two] [or] [Level three] LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
   4. Connect to system through a wireless router connected to Level one LAN.
   5. Connect to system through a cellular data service.
   6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
   7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
   8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:
   1. Connect DDC controller through a communications port local to controller.
   2. Able to communicate with any DDC system controller that is directly connected [or with LAN] [or connected to DDC system].

G. Mobile Device:
1. Connect to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using [a dedicated application] [and] [secure web access].

H. Telephone Communications:
1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.
   a. Desktop and Portable Workstations:
      1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
      2) Have routines to automatically answer calls, and either file or display information sent remotely.
      3) Communications taking place over telephone lines shall be completely transparent to operator.
      4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.
   b. DDC Controllers:
      1) Not have modems unless specifically indicated for a unique controller.
      2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
      3) Analyze and prioritize alarms to minimize initiation of calls.
      4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
      5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
      6) Call default devices when communications cannot be established with primary devices.

I. Critical Alarm Reporting:
1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

J. Simultaneous Operator Use: Capable of accommodating up to [five] [10] [20] simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.07 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
   1. ATA 878.1, ARCNET.
   2. CEA-709.1-C.
   3. IP.
   4. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:
   1. ATA 878.1, ARCNET.
   2. CEA-709.1-C.
   3. IP.
   4. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:
   1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. EIA-485A.
4. IP.
5. IEEE 8802-3, Ethernet.

2.08 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:
   1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
   2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
   3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
   4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. CEA-709.1-C Protocol:
   1. DDC system shall be an open implementation of LonWorks technology using CEA 709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.
   2. LNS shall be used for all network management including addressing and binding of network variables.
      a. Final LNS database shall be submitted with Project closeout submittals.
      b. All devices shall be online and commissioned into LNS database.
   3. All devices connected to DDC system network(s) shall use CEA-709.1-C protocol and be installed so SCPT output from any node on network can be bound to any other node in the domain.

D. Industry Standard Protocols:
   1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
      a. ASHRAE 135.
      b. CEA-709.1-C.
   2. Operator workstations and network controllers shall communicate through [ASHRAE 135] [or] [CEA-709.1-C] protocol.
   3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
   4. Portions of DDC system networks using CEA-709.1-C communication protocol shall be an open implementation of LonWorks technology using CEA-709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
   6. Gateways shall be used to connect networks and network devices using different protocols.

2.09 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location.

B. Performance Requirements:
   1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
   2. Energy Star compliant.

C. Personal Computer:
   1. Minimum Processor Speed: <Insert gigahertz>.
2. RAM:
   b. Speed and Type: [1333] MHz.

3. Hard Drive:
   a. Media: [Solid state] [Rotating disc, nominal rotational speed of 7200 rpm] [Hybrid solid-state and rotating disc].
   b. Number of Hard Drives: [One] [Two].
   c. Capacity: [Insert number and measurement unit].
   d. Minimum Average Seek Time: [Insert number and measurement unit].
   e. Cache Buffer Size: [Insert number and measurement unit].

4. Optical Drive:
   a. Type: [Insert type].
   b. Minimum Average Access Time: [Insert number] ms.
   c. Data Transfer Speed: [Insert number] [MB] [TB]/s.
   d. Reading Formats: Data, audio, recordable, [Insert other] and rewritable.

5. Optical Read and Write Drive:
   a. Include with at least 2 MB of data buffer.
   b. Type: [Insert type].
   c. Minimum Data Buffer Capacity: [Insert number and measurement unit].
   d. Minimum Average Access Time: [Insert number] ms.
   e. Nominal Data Transfer Rates:
      1) Reading: [Insert number] [MB] [TB]/s.
      2) Writing: [Insert number] [MB] [TB]/s.
   f. Average access time of 150 ms or less.
   g. MTBF of at least 100,000 power-on hours.

6. At least four expansion slots of [32] [64] [Insert number] bit.

7. Video Card:
   a. Resolution: [1920 by 1200] [Insert values] pixels.
   b. RAM: [Insert number] [MB] [GB] [TB].
   c. Controller Speed: [Insert number] [MHz] [GHz].
   d. On-Board Memory Speed: [Insert number] [MHz] [GHz].
   e. On-Board Memory Data Width: [Insert number] bit.

8. Sound Card:
   a. At least 128 voice wavetable synthesis.
   b. Capable of delivering three-dimensional sound effects.
   c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

9. Network Interface Card: Include card with connection, as applicable.
   a. 10-100-1000 base TX Ethernet with RJ45 connector port.
   b. 100 base FX Ethernet with SC or ST port.
   c. Wireless Ethernet, 802.11 a/b/g/n.
   1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
   2. I/O Ports:
      a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
      b. One serial port.
      c. One parallel port.
      d. Two PS/2 ports.
      e. One RJ-45.
      f. One stereo line-in and headphone/line-out on back panel.
      g. One microphone and headphone connector on front panel.
      h. One IEEE 1394 on front and back panel with PCI-e card.
      i. One ESATA port on back panel.
   3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:
   1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches in front of workstation.

F. Pointing Device:
1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches in front of workstation.

G. Flat Panel Display Monitor:
1. Display:
   a. Color display with <Insert inches> diagonal viewable area.
   b. [Digital] [or] [analog] input signal.
   c. Aspect Ratio: [16 to 9].
   d. Anti-glare display.
   e. Response Time: <Insert number> ms.
   f. Dynamic Contrast Ratio: [50000 to 1].
   g. Brightness: [250 cd/sq. m].
   h. Tilt adjustable base.
   i. Energy Star compliant.
   j. Resolution: [1920 by 1080] pixels at 60 Hz with pixel size of [0.277] mm or smaller.
   k. Number of Displays: [One] [Two].

H. Speakers:
1. Two, with individual controls for volume, bass and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.010 PORTABLE WORKSTATIONS

A. Description: A self-contained computer designed to allow for normal use in different locations and conditions.

B. Performance Requirements:
1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.
3. Hardware and software shall support local down-loading to DDC controllers.
4. Data transfer rate to DDC controller shall be at network speed.

C. Processor:
1. Minimum Processor Speed: <Insert gigahertz>.
2. RAM:
   a. Capacity: <Insert value> [GB] [TB].
   b. Speed and Type: <Insert value> MHz, .
3. Hard Drive:
   a. Media: [Solid state] [Rotating disc, nominal rotational speed of 7200 rpm] [Hybrid solid-state and rotating disc].
   b. Number of Hard Drives: [One] [Two].
   c. Capacity: <Insert number and measurement unit>.
   d. Minimum Average Seek Time: <Insert number and measurement unit>.
   e. Cache Buffer Size: <Insert number and measurement unit> of RAM.
4. Video Card: <Insert number and measurement unit> of RAM.

D. Input and Output Ports:
1. Serial port.
2. Shared port for external keyboard or mouse.
3. Four USB 3.0 ports.
4. HDMI port.
5. Ethernet port.
6. IEEE 1394 port.

E. Battery:
1. Capable of supporting operation of portable workstation for a minimum of 8 hours.
2. Battery life of at least three years.
3. Battery charge time of less than three hours.
4. Spare Battery(ies). [One] [Two].

F. Keyboard:
1. 85-key backlit keyboard.
2. Full upper- and lowercase ASCII keyset.

G. Integral Pointing Device: Touchpad with two buttons or equivalent pointing device.

H. Display:
1. <Insert inches> diagonal or larger high-definition WLED color display.
2. Anti-glare screen.
3. 1920 by 1080 pixel resolution.
4. Brightness: 300 nits.

I. Network Interface Card: Include card with connection, as application.
1. 10-100-1000 base TX Ethernet with RJ45 connector port.
2. 100 base FX Ethernet with SC or ST port.

J. Digital Video Disc Rewrite Recorder (DVD+/-RW):
1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
2. Nominal Data Transfer Rates:
   a. Reading: <Insert number> [MB] [TB]/s.
   b. Writing: <Insert number> [MB] [TB]/s.
3. 160-ms access time.

K. Accessories:
1. Nylon carrying case.
2. Docking station.
3. Mobile broadband card.
5. <Insert value> [GB] [TB] portable hard drive.
7. Category 6a patch cable. Minimum cable length shall be <Insert length>.
8. HDMI cable. Minimum cable length shall be <Insert length>.

2.011 PORTABLE OPERATOR TERMINAL

A. Description: Handheld device with integral keypad or touch screen operator interface.

B. Display: Multiple lines of text display for use in operator interaction with DDC system.

C. Cable: Flexible coiling cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports or instruments with an integral LAN port. As an alternative to hardwired connection, POT shall be accessible to DDC controllers through a wireless network connection.

D. POT shall be powered through network connection.

E. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

F. POT shall give operator the ability to do the following:
1. Display and monitor BI point status.
2. Change BO point set point (on or off, open or closed).
3. Display and monitor analog point values.
4. Change analog control set points.
5. Command a setting of AO point.
6. Display and monitor I/O point in alarm.
7. Add a new or delete an existing I/O point.
8. Enable and disable I/O points, initiators, and programs.
9. Display and change time and date.
10. Display and change time schedules.
11. Display and change run-time counters and run-time limits.
12. Display and change time and event initiation.
13. Display and change control application and DDC parameters.
14. Display and change programmable offset values.
15. Access DDC controller initialization routines and diagnostics.

2.012 PRINTERS

A. Color Inkjet Printer:
1. Inkjet technology with true four-color printing (black, cyan, magenta, and yellow).
2. Print quality of 1200 by 600 dots per inch with black on inkjet paper and 4800 by 1200 dots per inch color printing on premium photo paper.
3. Rated speed of <Insert number> pages per minute printing black and white in normal mode and <Insert number> pages per minute printing color in normal mode.
4. Two paper trays; one tray with <Insert number> sheet capacity, and one tray with <Insert number> sheet capacity.
5. Capable of handling letter- and legal-size paper and overhead transparencies.
6. <Insert number> MB of RAM.
7. Duplex printing (printing on both sides of paper).

2.013 SYSTEM SOFTWARE

A. System Software Minimum Requirements:
1. Real-time multitasking and multiuser [32-] [or] [64]-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple-network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:
1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
   a. Operator access to DDC system shall be under password control.
b. An alphanumeric password shall be field assignable to each operator.
c. Operators shall be able to access DDC system by entry of proper password.
d. Operator password shall be same regardless of which computer or other interface means is used.
e. Additions or changes made to passwords shall be updated automatically.
f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
g. Software shall have at least five access levels.
h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:
   a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
   b. Include at least 32 segregation groups.
   c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
   d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
   e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
   f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

8. Operators shall be able to perform commands including, but not limited to, the following:
   a. Start or stop selected equipment.
   b. Adjust set points.
   c. Add, modify, and delete time programming.
   d. Enable and disable process execution.
   e. Lock and unlock alarm reporting for each point.
   f. Enable and disable totalization for each point.
   g. Enable and disable trending for each point.
   h. Override control loop set points.
   i. Enter temporary override schedules.
   j. Define holiday schedules.
   k. Change time and date.
   l. Enter and modify analog alarm limits.
   m. Enter and modify analog warning limits.
   n. View limits.
   o. Enable and disable demand limiting.
   p. Enable and disable duty cycle.
   q. Display logic programming for each control sequence.

9. Reporting:
   a. Generated automatically and manually.
   b. Sent to displays, printers and disk files.
   c. Types of Reporting:
      1) General listing of points.
      2) List points currently in alarm.
      3) List of off-line points.
      4) List points currently in override status.
      5) List of disabled points.
      6) List points currently locked out.
      7) List of items defined in a "Follow-Up" file.
      8) List weekly schedules.
      9) List holiday programming.
10) List of limits and deadbands.
10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:
1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
   a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
   b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
   c. Keyboard equivalent shall be available for those operators with that preference.
20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:
   a. On-line context-sensitive help utility to facilitate operator training and understanding.
   b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

c. Available for Every Menu Item:
   1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
   a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
   b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
      1) Define background screens.
      2) Define connecting lines and curves.
      3) Locate, orient and size descriptive text.
      4) Define and display colors for all elements.
      5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
   1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
   2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
      a. Room layouts with room identification and name.
      b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
      c. Location and identification of each hardware point being controlled or monitored by DDC system.
   3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
      a. Chilled-water system.
      b. Condenser-water system.
      c. Energy-recovery [system] [and] [unit].
      d. Fuel system.
      e. Heating hot-water system.
      f. Steam system.
      g. Air-handling [system] [and] [unit].
      h. Fan.
      i. Pump.
      j. Rooftop unit.
      k. Terminal unit.
   4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
   5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, [gateways] [operator workstations] [and] [other network devices].

E. Customizing Software:
   1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
   2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
   3. As a minimum, include the following modification capability:
      a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
      b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.

e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.

f. Point related change capability shall include the following:
   1) System and point enable and disable.
   2) Run-time enable and disable.
   3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
   4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:
   1) Enable and disable of software programs.
   2) Programming changes.
   3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
   a. Proportional control (P).
   b. Proportional plus integral (PI).
   c. Proportional plus integral plus derivative (PID).
   d. Adaptive and intelligent self-learning control.
      1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
      2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:
   1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
   2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
   3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
   4. Alarms display shall include the following:
      a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."

c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."

d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

6. Send e-mail alarm messages to designated operators.

7. Send e-mail, page, text and voice messages to designated operators for critical alarms.

8. Alarms shall be categorized and processed by class.

a. Class 1:
   1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
   2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
   3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

b. Class 2:
   1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
   2) Acknowledgement may be through a multiple alarm acknowledgment.

c. Class 3:
   1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
   2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
   3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
   4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:
   1) Routine maintenance or other types of warning alarms.
   2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.

2. Each report shall be definable as to data content, format, interval and date.

3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [workstation] [server] for historical reporting.

4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.

5. Reports and logs shall be stored on [workstation] [and] [server] hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.

2. Alarm: All current alarms, except those in alarm lockout.

3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:
   a. Alarm history.
   b. System messages.
   c. System events.
   d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75% of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

K. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
   1. Each trend shall include interval, start time, and stop time.
   2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [workstation] [server] hard drives.
   3. Data shall be retrievable for use in spreadsheets and standard database programs.

L. Programming Software:
   1. Include programming software to execute sequences of operation indicated.
   2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
   3. Programming software shall be [as follows] [any of the following] [one of the following]:
      a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
         1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
         2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
      b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
      c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
   4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

M. Database Management Software:
   1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
   2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
   3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
      a. Backup.
      b. Purge.
4. Database management software shall support the following:
   a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
   b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
   c. Backup: Include means to create a database backup file and select a storage location.
   d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:
   a. Ready.
   b. Purging record from a database.
   c. Action failed.
   d. Refreshing statistics.
   e. Restoring database.
   f. Shrinking a database.
   g. Backing up a database.
   h. Resetting Internet information services.
   i. Starting network device manager.
   j. Shutting down the network device manager.
   k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.

7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.

8. Monitoring settings window shall have the following sections:
   a. Allow operator to set and review scan intervals and start times.
   b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
   c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
   d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
   e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.

9. Monitoring settings taskbar shall include the following informational icons:
   a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
   b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
   c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

2.014 OFFICE APPLICATION SOFTWARE

A. Include current version of office application software at time of Substantial Completion.

B. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."
   1. Database.
   2. E-mail.
   3. Presentation.
   4. Publisher.
   5. Spreadsheet.
2.015 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:
   1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
   2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
   3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
   4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
   5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
   6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.016 CEA-709.1-C NETWORK HARDWARE

A. Routers:
   1. Network routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and include connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
   2. IP Routers:
      a. Perform layer three routing of CEA-709.1-C packets over an IP network according to CEA-852-B.
      b. Include appropriate connection to the IP network and connections to CEA-709.3 TP/FT-10 or TP/XF-1250 network.
      c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CEA-852-B Configuration Server (for CEA-852-B configuration), but shall not rely on these services for configuration.
      d. Capable of manual configuration via a console RS-232 port.

B. Gateways:
   1. Perform bidirectional protocol translation from one non-CEA-709.1-C protocol to CEA-709.1-C.
   2. Incorporate a network connection to a TP/FT-10 network according to CEA-709.3 and a connection for a non-CEA-709.1-C network.

2.017 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:
1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:
1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:
1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
   a. Network Controllers: [50] [60] [70] percent.
   b. Programmable Application Controllers: Not less than [60] [70] [80] percent.
   c. Application-Specific Controllers: Not less than [70] [80] [90] percent.
2. Memory shall support DDC controller's operating system and database and shall include the following:
   a. Monitoring and control.
   b. Energy management, operation and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
1. Network Controllers:
   a. [10] [20] percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: [Two] [Three].
      2) AOs: [Two] [Three].
      3) BIs: [Three] [Five].
      4) BOs: [Three] [Five].
2. Programmable Application Controllers:
   a. [10] [20] percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: [Two] [Three].
      2) AOs: [Two] [Three].
      3) BIs: [Three] [Five].
      4) BOs: [Three] [Five].
3. Application-Specific Controllers:
   a. [0] percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: [One] [Two].
      2) AOs: [One] [Two].
      3) BIs: [One] [Two].
      4) BOs: [One] [Two].

I. Maintenance and Support: Include the following features to facilitate maintenance and support:
1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. General Requirements for CEA-709.1-C DDC Controllers:
1. Controllers shall be LonMark certified.
2. Distinguishable and accessible switch, button, or pin, when pressed shall broadcast its 48-bit Node ID and Program ID over network.
3. TP/FT-10 transceiver according to CEA-709.3 and connections for TP/FT-10 control network wiring.
4. TP/XF-1250 transceiver according to CEA-709.3 and connections for TP/XF-1250 control network wiring.
6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
8. Locally powered, not powered through network connection.
9. Functionality required to support applications indicated, including, but not limited to, the following:
   a. Input and outputs indicated and as required to support sequence of operation and application in which it is used. SNVTs shall have meaningful names identifying the value represented by an SNVT. Unless an SNVT of an appropriate engineering type is unavailable, all network variables shall be of an SNVT with engineering units appropriate to value the variable represents.
   b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of an SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.
10. Programmable controllers shall conform to LonMark Interoperability Guidelines and have LonMark certification.

K. Input and Output Point Interface:
1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. Als:
   a. Als shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
   b. Als shall be compatible with, and field configurable to, sensor and transmitters installed.
   c. Controller Als shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [8] [12] bits or better to comply with accuracy requirements indicated.
   d. Signal conditioning including transient rejection shall be provided for each Al.
   e. Capable of being individually calibrated for zero and span.
   f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
5. AOs:
   a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [8] [12] bits or better to comply with accuracy requirements indicated.
   b. Output signals shall have a range of [4 to 20 mA dc] [or] [zero- to 10-V dc] as required to include proper control of output device.
   c. Capable of being individually calibrated for zero and span.
   d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
6. BIs:
   a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
c. Bls shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
d. Bls shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.
e. Pulse accumulation input points shall comply with all requirements of Bls and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator’s command.

7. BOs:
   a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
      1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
      2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.
   b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
   c. BOs shall be selectable for either normally open or normally closed operation.
   d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
   e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate actuator to one end of its stroke once every [12] [24] hours for verification of operator tracking.

2.018 NETWORK CONTROLLERS

A. General Network Controller Requirements:
   1. Include adequate number of controllers to achieve performance indicated.
   2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
   3. Controller shall have enough memory to support its operating system, database, and programming requirements.
   4. Data shall be shared between networked controllers and other network devices.
   5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   6. Controllers that perform scheduling shall have a real-time clock.
   7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
   8. Controllers shall be fully programmable.

B. Communication:
   1. Network controllers shall communicate with other devices on DDC system Level one network.
   2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:
   1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
   2. Local Keypad and Display:
      a. Equip controller with local keypad and digital display for interrogating and editing data.
      b. Use of keypad and display shall require security password.

D. Serviceability:
   1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least [72] [96] hours.

2.019 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:
   1. Include adequate number of controllers to achieve performance indicated.
   2. Controller shall have enough memory to support its operating system, database, and programming requirements.
   3. Data shall be shared between networked controllers and other network devices.
   4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   5. Controllers that perform scheduling shall have a real-time clock.
   6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
   7. Controllers shall be fully programmable.

B. Communication:
   1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:
   1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
   2. Local Keypad and Display:
      a. Equip controller with local keypad and digital display for interrogating and editing data.
      b. Use of keypad and display shall require security password.

D. Serviceability:
   1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
   2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
   3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.020 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
   1. Capable of standalone operation and shall continue to include control functions without being connected to network.
   2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:
   1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
   2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.021 CONTROLLER SOFTWARE

A. General Controller Software Requirements:
   1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
   2. I/O points shall be identified by up to 30-character name and up to 16-character point descriptor. Same names shall be used at operator workstations.
   3. Control functions shall be executed within controllers using DDC algorithms.
   4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:
   1. Operator access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
   3. Operator log-on and log-off attempts shall be recorded.
   4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:
   1. Weekly Schedule:
      a. Include separate schedules for each day of week.
      b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
      c. Each schedule may consist of up to 10 events.
      d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
   2. Exception Schedules:
      a. Include ability for operator to designate any day of the year as an exception schedule.
      b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
   3. Holiday Schedules:
      a. Include capability for operator to define up to 99 special or holiday schedules.
      b. Schedules may be placed on scheduling calendar and will be repeated each year.
      c. Operator shall be able to define length of each holiday period.

D. System Coordination:
   1. Include standard application for proper coordination of equipment.
   2. Application shall include operator with a method of grouping together equipment based on function and location.
   3. Group may then be used for scheduling and other applications.

E. Binary Alarms:
   1. Each binary point shall be set to alarm based on operator-specified state.
   2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:
   1. Each analog object shall have both high and low alarm limits.
   2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:
   1. Operator shall be able to determine action to be taken in event of an alarm.
   2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:
   1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:
   1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
   2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
   3. Demand reduction shall be accomplished by the following means:
      a. Reset air-handling unit supply temperature set points.
      b. Reset space temperature set points.
      c. De-energize equipment based on priority.
   4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
   5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
   6. Include means operator to make the following changes online:
      a. Addition and deletion of loads controlled.
      b. Changes in demand intervals.
      c. Changes in demand limit for meter(s).
      d. Maximum shutoff time for equipment.
      e. Minimum shutoff time for equipment.
      f. Select rotational or sequential shedding and restoring.
      g. Shed and restore priority.
   7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:
      a. Total electric consumption.
      b. Peak demand.
      c. Date and time of peak demand.
      d. Daily peak demand.

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:
   1. Support any of the following control loops, as applicable to control required:
      a. Two-position (on/off, open/close, slow/fast) control.
      b. Proportional control.
      c. Proportional plus integral (PI) control.
      d. Proportional plus integral plus derivative (PID) control.
         1) Include PID algorithms with direct or reverse action and anti-windup.
         2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
         3) Controlled variable, set point, and PID gains shall be operator-selectable.
      e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
N. Energy Calculations:
   1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
   2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
   3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:
   1. BO points shall be protected from short cycling.
   2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:
   1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
   2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:
   1. Include software to totalize run-times for all BI and BO points.
   2. A high run-time alarm shall be assigned, if required, by operator.

2.022 ENCLOSURES

A. General Enclosure Requirements:
   1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
   2. Do not house more than one controller in a single enclosure.
   3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
   4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
   5. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches [60 inches high.
   6. Individual wall-mounted double-door enclosures shall not exceed 60 inches wide and 36 inches high.
   7. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
   8. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:
   1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
   2. Arrange layout to group similar products together.
   3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
   4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
   5. Terminate field cable and wire using heavy-duty terminal blocks.
   6. Include spare terminals, equal to not less than [10] percent of used terminals.
   7. Include spade lugs for stranded cable and wire.
   8. Install a maximum of two wires on each side of a terminal.
   9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
  10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
  11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:
1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:
1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:
   a. Enclosure size less than 24 in.: [0.053 in.] [or] [0.067 in.] thick.
   b. Enclosure size 24 in. and larger: [0.067 in.] [or] [0.093 in.] thick.
3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be [white] [ANSI 61 gray] [selected by Architect] [manufacturer's standard].
   b. Interior color shall be [white] [ANSI 61 gray] [manufacturer's standard].
4. Hinged door full size of front face of enclosure and supported using:
   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.
5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Size less than 24 in.: [Solid] [or] [Perforated] steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid [aluminum, 0.10 in.] [or] [steel, 0.093 in.] thick.
6. Internal panel mounting hardware, grounding hardware and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
7. Construct enclosure of steel, not less than the following:
   a. Size Less Than 24 Inches: [0.053 inch] [or] [0.067 inch] thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be [white] [ANSI 61 gray] [as selected by Architect] [manufacturer's standard].
   b. Interior color shall be [white] [ANSI 61 gray] [manufacturer's standard].
9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
   a. Sizes through 24 Inches Tall: Two hinges.
   b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
   c. Sizes Larger 48 Inches Tall: Four hinges.
10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    a. Size Less Than 24 Inches: [Solid] [or] [perforated] steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid [aluminum, 0.10 inch] [or] [steel, 0.093 inch] thick.
12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Accessories:
1. Electric Heater:
   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from zero to 100 deg F.
   c. Capacity: 100, 200, 400, and 800 W as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.
2. Ventilation Fans, Filtered Intake and Exhaust Grilles:
   a. Number and size of fans, filters and grilles as required by application.
   b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
   c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
   d. Thermostatic control with adjustable set point from 32 to 140 deg F.
   e. Airflow Capacity at Zero Pressure:
      1) 4-Inch Fan: 100 cfm.
      2) 6-Inch Fan: 240 cfm.
      3) 10-Inch Fan: 560 cfm.
   f. Maximum operating temperature of 158 deg F.
   g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
   h. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
   i. Dynamically balanced impellers molded from polycarbonate material.
   j. Fan furnished with power cord and polarized plug for power connection.
   k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
   l. Removable Intake and Exhaust Grilles: [ABS plastic] [or] [stainless steel] of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
   m. Filters for NEMA 250, Type 1 Enclosures: Washable [foam] [or] [aluminum], of a size to match intake grille.
   n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.
3. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:
   a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.
4. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:
   a. 0.125-inch- thick, polycarbonate window mounted in enclosure door material.
   b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
c. Window kit shall be factory or shop installed before shipment to Project.

5. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:
   a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.


2.023 RELAYS

A. General-Purpose Relays:
   1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
   2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
   3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
   4. Construct the contacts of either silver cadmium oxide or gold.
   5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
   6. Relays shall have LED indication and a manual reset and push-to-test button.
   7. Performance:
      a. Mechanical Life: At least 10 million cycles.
      b. Electrical Life: At least 100,000 cycles at rated load.
      c. Pickup Time: 15 ms or less.
      d. Dropout Time: 10 ms or less.
      e. Pull-in Voltage: 85 percent of rated voltage.
      f. Dropout Voltage: 50 percent of nominal rated voltage.
      g. Power Consumption: 2 VA.
      h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
   8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
   9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
   10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:
   1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
   2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
   3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
   4. Construct the contacts of either silver cadmium oxide or gold.
   5. Enclose the relay in a dust-tight cover.
   6. Include knob and dial scale for setting delay time.
   7. Performance:
      a. Mechanical Life: At least 10 million cycles.
      b. Electrical Life: At least 100,000 cycles at rated load.
      c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
      d. Repeatability: Within 2 percent.
      e. Recycle Time: 45 ms.
      f. Minimum Pulse Width Control: 50 ms.
      g. Power Consumption: 5 VA or less at 120-V ac.
      h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
   8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
   9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
   10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:
1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Description:
   a. On-off control and status indication in a single device.
   b. LED status indication of activated relay and current trigger.
   c. Closed-Open-Auto override switch located on the load side of the relay.
2. Performance:
   a. Ambient Temperature: Minus 30 to 140 deg F.
3. Status Indication:
   a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
   b. Current Sensor Range: As required by application.
   c. Current Set Point: [Fixed] [Adjustable] [Fixed or adjustable as required by application].
   d. Current Sensor Output:
      1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
      2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
      3) Analog, zero- to 5- or 10-V dc.
      4) Analog, 4 to 20 mA, loop powered.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.024 ELECTRICAL POWER DEVICES

A. Transformers:
1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least [40] [100] VA.
3. Transformer shall have both primary and secondary fuses.
B. DC Power Supply:
1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:
   a. Output voltage nominally 25-V dc within 5 percent.
   b. Output current up to 100 mA.
   c. Input voltage nominally 120-V ac, 60 Hz.
   d. Load regulation within 0.5 percent from zero- to 100-mA load.
   e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
   f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.025 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:
1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   a. Larger-capacity units shall be provided for systems with larger connected loads.
   b. UPS shall provide five minutes of battery power.
3. Performance:
   a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
   b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
   c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
   d. On Battery Output Voltage: Sine wave.
   e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
   f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
   g. Transfer Time: 6 ms.
   h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.
4. UPS shall be automatic during fault or overload conditions.
5. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
6. Include front panel with power switch and visual indication of power, battery, fault and temperature.
7. Unit shall include an audible alarm of faults and front panel silence feature.
8. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
9. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure)[and connect the points to the DDC system.
10. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
11. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:
1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
   b. UPS shall provide [five] [10] minutes of battery power.
3. Performance:
   a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
   b. Power Factor: Minimum 0.97 at full load.
   c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
   d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
2.026 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:
   1. Products in this paragraph are intended for use with the following:
      a. Main air and signal air to pneumatically controlled instruments, actuators and other control devices and accessories.
      b. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
   2. Copper Tubing:
      a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B75.
      b. Performance, dimensions, weight and tolerance according to ASTM B280.
      c. Diameter, as required by application, not less than nominal 0.25 inch.
      d. Wall thickness, as required by the application, but not less than 0.030 inch.
   3. Copper Tubing Connectors and Fittings:
      a. Brass, compression type.
      b. Brass, solder-joint type.
   4. Polyethylene Tubing:
      a. Fire-resistant black virgin polyethylene according to ASTM D1248, Type 1, Class C and Grade 5.
      b. Tubing shall comply with stress crack test according to ASTM D1693.
      c. Diameter, as required by application, of not less than nominal 0.25 inch.
   5. Polyethylene Tubing Connectors and Fittings:
      a. Brass, barbered fittings.
      b. Brass, compression type.

B. Process Tubing:
   1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
   2. Copper Tubing:
      a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B75.
      b. Performance, dimensions, weight and tolerance according to ASTM B280.
      c. Diameter, as required by application, of not less than nominal 0.25 inch.
      d. Wall thickness, as required by application, but not less than 0.030 inch.
   3. Copper Tubing Connectors and Fittings:
      a. Brass, compression type.
      b. Brass, solder-joint type.

2.027 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.
   1. Wire size shall be at least [No. 18] [No. 16] [No. 14] AWG.
   2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
   3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
   4. Conductor colors shall be black (hot), white (neutral), and green (ground).
   5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:
   1. Wire size shall be a minimum [No. 18] [No. 20] [No. 22] AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
1. Wire size shall be a minimum [No. 18] [No. 20] [No. 22] AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable.
3. Cable shall be plenum rated.
4. Cable shall comply with NFPA 70.
5. Cable shall have a unique color that is different from other cables used on Project.

2.028 CONTROL POWER WIRING AND RACEWAYS
A. Comply with requirements for electrical power conductors and cables.
B. Comply with requirements for electrical power raceways and boxes.

2.029 ACCESSORIES
A. Damper Blade Limit Switches:
1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Manual Valves:
1. Needle Type:
   a. PTFE packing.
   b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
   c. Aluminum T-bar handle.
   d. Include tubing connections.
2. Ball Type:
   b. Ball: Type 316 stainless steel.
   c. Stem: Type 316 stainless steel.
   d. Seats: Reinforced PTFE.
   e. Packing Ring: Reinforced PTFE.
   f. Lever: Stainless steel with a vinyl grip.
   g. 600 WOG.
   h. Threaded end connections.
2.030 IDENTIFICATION

A. Instrument Air Pipe and Tubing:
1. Engraved tag shall bear the following information:
   a. Service (Example): "Instrument Air."
   b. Pressure Range (Example): 0 to 30 psig.
2. Letter size shall be a minimum of 0.25 inch high.
3. Tag shall consist of white lettering on blue background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded blue with contrasting white center exposed by engraving through outer layer.
5. Include tag with a brass grommet, chain and S-hook.

B. Control Equipment, Instruments, and Control Devices:
1. Engraved tag bearing unique identification.
   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size shall be as follows:
   a. Operator Workstations: Minimum of 0.5 inch high.
   b. Printers: Minimum of 0.5 inch high.
   c. DDC Controllers: Minimum of 0.5 inch high.
   d. Gateways: Minimum of 0.5 inch high.
   e. Repeaters: Minimum of 0.5 inch high.
   f. Enclosures: Minimum of 0.5 inch high.
   g. Electrical Power Devices: Minimum of 0.25 inch high.
   h. UPS units: Minimum of 0.5 inch high.
   i. Accessories: Minimum of 0.25 inch high.
   j. Instruments: Minimum of 0.25 inch high.
   k. Control Damper and Valve Actuators: Minimum of 0.25 inch high.
3. Tag shall consist of white lettering on black background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
5. Tag shall be fastened with drive pins.
6. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Valve Tags:
1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

D. Raceway and Boxes:
1. Comply with requirements for identification.
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

E. Equipment Warning Labels:
1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

2.031 SOURCE QUALITY CONTROL

A. Product(s) and material(s) will be considered defective if [it does] [they do] not pass tests and inspections.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.
   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.02 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:
   1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
   2. Equipment to Be Connected:
      b. Air-handling units.
      c. Roof-top units.
      d. Dedicated outdoor-air units.
      e. Switchboards.
      f. Motor-control centers.
      g. Variable-frequency controllers.
      h. UPS
      i. Refrigerant monitoring.

B. Communication Interface to Other Building Systems:
   1. DDC system shall have a communication interface with systems having a communication interface.
   2. Systems to Be Connected:
      a. Automated water treatment systems.
      b. Power monitoring.
      c. Lighting controls...
      d. Fire-alarm system...
      e. Access controls.

3.03 Intrusion detection. Perimeter security. CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
1. DDC control dampers.
2. Airflow sensors and switches.
3. Pressure sensors.

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
1. DDC control valves.
3. Tank-mounted sensors, switches and transmitters.

3.04 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer and supervise installation for compliance with requirements.
1. [Programmable application] [or] [application-specific] controller.
2. Unit-mounted DDC control dampers and actuators.
3. Unit-mounted airflow sensors, switches and transmitters.
4. Unit-mounted gas sensors and transmitters.
5. Unit-mounted leak-detection switches.
6. Unit-mounted speed sensors, switches and transmitters.
7. Unit-mounted pressure sensors, switches and transmitters.
8. Unit-mounted temperature sensors, switches and transmitters.

B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.
1. [Programmable application] [or] [application-specific] controller.
2. Electric damper actuator. Unit-mounted flow and pressure sensors, transmitters and transducers.
3. Unit-mounted temperature sensors.
4. Relays.

C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.
1. [Programmable application] [or] [application-specific] controller.
2. Unit-mounted temperature sensors.
4. Relays.

3.05 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a <insert value> force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinsh openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies.
G. Seal penetrations made in acoustically rated assemblies.

H. Welding Requirements:
1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:
1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.
2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.06 OPERATOR WORKSTATION INSTALLATION

A. Desktop Workstations Installation:
1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:
1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:
1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's[ and Architect's] review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.07 POT INSTALLATION
A. Install [one] [two] portable operator terminal(s).
B. Turn over POTs to Owner at Substantial Completion.
C. Install software on each POT and verify that software functions properly.

3.08 PRINTER INSTALLATION
A. Provide the following printer(s) at location(s) directed by Owner:
   1. Color Inkjet: Quantity, [one] [one per desktop workstation].
   2. Dot Matrix: Quantity, [one] [one per desktop workstation].
B. Install printer software on workstations and verify that software functions properly.

3.09 GATEWAY INSTALLATION
A. Install gateways if required for DDC system communication interface requirements indicated.
   1. Install gateway(s) required to suit indicated requirements.
B. Test gateway to verify that communication interface functions properly.

3.010 ROUTER INSTALLATION
A. Install routers if required for DDC system communication interface requirements indicated.
   1. Install router(s) required to suit indicated requirements.
B. Test router to verify that communication interface functions properly.

3.011 CONTROLLER INSTALLATION
A. Install controllers in enclosures to comply with indicated requirements.
B. Connect controllers to field power supply and to UPS units where indicated.
C. Install controller with latest version of applicable software and configure to execute requirements indicated.
D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
E. Installation of Network Controllers:
   1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within [72 inches] [84 inches] of finished floor.
F. Installation of Programmable Application Controllers:
   1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within [72 inches] [84 inches] of finished floor.
G. Application-Specific Controllers:
   1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.012 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:
   1. Gateways.
   2. Routers.
   3. Controllers.
   4. Electrical power devices.
   5. UPS units.
   6. Relays.
   7. Accessories.
   8. Instruments.
   9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:
   1. For NEMA 250, [Type 1] <Insert type> Enclosures: Use [painted steel] [galvanized-steel] [corrosion-resistant-coated steel] strut and hardware.
   2. For NEMA 250, [Type 4] [Type 4X] Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
   3. Install plastic caps on exposed cut edges of strut.

C. Align [top] [or] [bottom] of adjacent enclosures[ of like size].

D. Install floor-mounted enclosures located [in mechanical equipment rooms ]on concrete housekeeping pads. Attach enclosure legs using [galvanized] [or] [stainless-steel anchors].

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.013 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements for electrical power circuit breakers.

D. Comply with requirements for electrical power conductors and cables.

E. Comply with requirements for electrical power raceways and boxes.

3.014 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

B. Install [self-adhesive labels] [laminated acrylic or melamine plastic signs] with unique identification on face for each of the following:
   1. Operator workstation.
   2. Printer.
   3. Gateway.
   4. Router.
   5. DDC controller.
   7. Electrical power device.
   8. UPS unit.
C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control [damper] [and] [valve] actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:
   1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
   2. Shall be located in highly visible location near power service entry points.

3.015 NETWORK INSTALLATION

A. Install balanced twisted pair cable when connecting between the following network devices[ located in same building]:
   1. Operator workstations.
   2. Operator workstations and network controllers.
   3. Network controllers.

B. Install balanced twisted pair cable when connecting between the following:
   1. Gateways.
   2. Gateways and network controllers or programmable application controllers.
   3. Routers.
   4. Routers and network controllers or programmable application controllers.
   5. Network controllers and programmable application controllers.
   6. Programmable application controllers.
   7. Programmable application controllers and application-specific controllers.

C. Install cable in continuous raceway.
   1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.016 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:
   1. MAC Address:
      a. Every network device shall have an assigned and documented MAC address unique to its network.
      b. Ethernet Networks: Document MAC address assigned at its creation.
      c. ARCNET or MS/TP networks: Assign from 00 to 64.
   2. Network Numbering:
      a. Assign unique numbers to each new network.
      b. Provide ability for changing network number through device switches or operator interface.
      c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

   3. Device Object Identifier Property Number:
      a. Assign unique device object identifier property numbers or device instances for each device network.
      b. Provide for future modification of device instance number by device switches or operator interface.
      c. LAN shall support up to 4,194,302 unique devices.

   4. Device Object Name Property Text:
      a. Device object name property field shall support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
   1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
   2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102."

5. Object Name Property Text for Other Than Device Objects:
   a. Object name property field shall support 32 minimum printable characters.
   b. Assign object name properties with plain-English names descriptive of application.
      1) Example 1: "Zone 1 Temperature."
      2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:
   a. Assign object identifier property numbers according to [Drawings] [or] [tables] indicated.
   b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.017 PIPING AND TUBING INSTALLATION

A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:
   1. Material Application:
      a. Install copper tubing, except as follows:
         1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.
         2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings and concealed in walls and connecting wall-mounted instruments with recessed connections.
      b. Install copper tubing, unless other accessible materials are indicated, for air signals to instruments including, but not limited to, the following:
         1) Sensors.
         2) Switches.
         3) Transmitters.
      c. Install drawn-temper copper tubing, except within 36 inches of device terminations tubing shall be annealed-tempered copper tubing.
      d. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
      e. Install [barbed] [or] [compression] fittings to connect polyethylene tubing to instruments, control devices, and accessories.
   2. Routing:
      a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.
      b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.
      c. Install piping and tubing plumb and parallel to and at right angles with building construction.
      d. Install multiple runs of tubing or piping in equally spaced parallel lines.
      e. Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.
      f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.
      g. Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.
   3. Support:
      a. According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches.
      b. Support copper tubing with copper hangers, clips, and tube trays.
c. Do not use tape for support or dielectric isolation.
d. Install supports at each change in direction and at each branch take off.
e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.
f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
h. Brace supports to prevent lateral movement.
i. Paint steel support members that are not galvanized or zinc coated.
j. Support polyethylene tubing same as copper tubing.

4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.

5. Protect exposed tubing in mechanical equipment rooms from mechanical damage within [76 inches] [84 inches] [96 inches] above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

6. Joining and Makeup:
a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
b. Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.
c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.
d. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.
e. Install tube fittings according to manufacturer's written instructions.
f. Do not make tubing connections to a fitting before completing makeup of the connection.
g. Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.
h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
i. Check tubing for correct diameter and wall thickness.
j. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
k. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.
l. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.
m. Protect piping and tubing from entrance of foreign matter.

7. Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

B. Identify piping and tubing as follows:
1. Every 50 feet of straight run.
2. At least once for each branch within 36 inches of main tee.
3. At each change in direction.
4. Within 36 inches of each ceiling, floor, roof and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. At each valve.
7. Mark each instrument tube connection with a number-coded identification. Each unique tube shall have same unique number at instrument connection and termination at opposite end of tube.

C. Isolation Valves Installation:
1. Install valves full size of piping and tubing.
2. Install at the following locations:
a. At each branch.
b. Before and after each PRV.
c. Before and after each air dryer.
d. At each control device.
3. Valves shall be located to be readily accessible from floor.
D. Process Tubing Installation:
1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:
   a. Meters.
   b. Sensors.
   c. Switches.
   d. Transmitters.
2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches.
3. Install NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.
4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
5. Support tubing independent of other trades.
6. Route tubing parallel to and at right angles to building construction.
7. Install tubing concealed in areas with ceilings.
8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
10. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with a single wrap of PTFE tape.
11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce the possibility of galling.
12. Do not make tubing connections to a fitting before completing makeup of the connection.
13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.
16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
18. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within [76 inches] [84 inches] [96 inches] above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

E. Isolation Valves Installation:
1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:
   b. Inlet to each instrument including, sensors, transmitters, switches, gages, and other control devices.
3. Locate valves to be readily accessible from floor.

3.018 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION
A. Comply with NECA 1.
B. Wire and Cable Installation:
1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
   a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
2. Provide strain relief.
3. Terminate wiring in a junction box.
   a. Clamp cable over jacket in junction box.
   b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
4. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
5. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
6. Use shielded cable to transmitters.
7. Use shielded cable to temperature sensors.
8. Perform continuity and meager testing on wire and cable after installation.

3.019 FIELD QUALITY CONTROL

A. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections.

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections [with the assistance of a factory-authorized service representative]:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Testing of Pneumatic and Air-Signal Tubing:
   a. Test for leaks and obstructions.
   b. Disconnect each pipe and tubing line before a test is performed, and blowout dust, dirt, trash, condensate and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Air from an oil-free compressor with an air dryer is an acceptable alternative for the test.
   c. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
   d. Connect a pressure source to near end of run with a needle valve between air supply and tubing run.
   e. Connect a pressure gage accurate to within 0.5 percent of test between the shutoff needle valve and tubing run under test.
   f. For system pressures above 30 psig, apply a pressure of 1.5 times operating pressure. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 1 psig.
   g. For system pressures 30 psig and below, apply a pressure of 2.0 times operating pressure to piping and tubing run. Record pressure in tubing run every 5 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 0.5 psig.

D. Testing:
1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.020 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:
   1. Verify that control dampers are installed correctly for flow direction.
   2. Verify that proper blade alignment, either parallel or opposed, has been provided.
   3. Verify that damper frame attachment is properly secured and sealed.
   4. Verify that damper actuator and linkage attachment is secure.
   5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
   6. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:
   1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
   2. Verify that control valves are installed correctly for flow direction.
   3. Verify that valve body attachment is properly secured and sealed.
   4. Verify that valve actuator and linkage attachment is secure.
   5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
   6. Verify that valve ball, disc or plug travel is unobstructed.
   7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:
   1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
   2. Verify that attachment is properly secured and sealed.
   3. Verify that conduit connections are properly secured and sealed.
   4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
   5. Inspect instrument tag against approved submittal.
   6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
   7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
   8. For temperature instruments:
      a. Verify sensing element type and proper material.
      b. Verify length and insertion.

3.021 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:
   1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
   2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
   3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:
   1. Check digital signals using a jumper wire.
   2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:
   1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
   3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
   4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:
   1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
   3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
   4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:
   1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
   2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.
3.022 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.
   1. Verify voltage, phase and hertz.
   2. Verify that protection from power surges is installed and functioning.
   3. Verify that ground fault protection is installed.
   4. If applicable, verify if connected to UPS unit.
   5. If applicable, verify if connected to a backup power source.
   6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.023 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:
   1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
   2. Test every I/O point throughout its full operating range.
   3. Test every control loop to verify operation is stable and accurate.
   4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop’s precision and stability via trend logs.
   5. Test and adjust every control loop for proper operation according to sequence of operation.
   6. Test software and hardware interlocks for proper operation. Correct deficiencies.
   7. Operate each analog point at the following:
      a. Upper quarter of range.
      b. Lower quarter of range.
      c. At midpoint of range.
   8. Exercise each binary point.
   9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
   10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.024 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:
   1. Detailed explanation for any items that are not completed or verified.
   2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
   3. HVAC equipment motors operate below full-load amperage ratings.
   4. Required DDC system components, wiring, and accessories are installed.
   5. Installed DDC system architecture matches approved Drawings.
   6. Control electric power circuits operate at proper voltage and are free from faults.
   7. Required surge protection is installed.
   8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:
1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.

F. Validation Test:
1. Verify operating performance of each I/O point in DDC system.
   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.
       1) Identify I/O points for future reference.
       2) Simulate abnormal conditions to demonstrate proper function of safety devices.
       3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. After 24 Hours of Second Validation Test:
   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:
1. Simulate HLC.
   a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an “alarm” condition, and 50 percent of total connected analog COV, one-
half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:
   a. Reaction to COV and alarm conditions during HLC.
   b. Ability to update DDC system database during HLC.
5. Passing test is contingent on the following:
   a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
   b. All alarms, both binary and analog, are reported and printed; none are lost.
   c. Compliance with response times specified.
6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:
   1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
   2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.025 FINAL REVIEW

A. Submit written request to Architect [and] [Construction Manager] when DDC system is ready for final review. Written request shall state the following:
   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.

B. Review by [Architect] [and] [Construction Manager] shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.
   1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
   2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
   3. Demonstration shall include, but not be limited to, the following:
      a. Accuracy and calibration of [10] [20] I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
      b. HVAC equipment and system hardwired and software safety functions are operating according to sequence of operation. Up to [10] [20] I/O points shall be randomly
selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Each [Network] [and] [Programmable Application] Controller:

1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.

2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

4) Electric Power: Ability to disconnect any controller safely from its power source.

5) Wiring Labels: Match control drawings.

6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.

2) Graphics are complete.

3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management.[ Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability.] Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.

2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.[ Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.]
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.

5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.

6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.

7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.

8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.

9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

10) Device and Network Management:
   a) Display of network device status.
   b) Display of BACnet Object Information.
   c) Silencing devices transmitting erroneous data.
   d) Time synchronization.
   e) Remote device re-initialization.
   f) Backup and restore network device programming and master database(s).
   g) Configuration management of routers.

3.026 ADJUSTING
A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.027 MAINTENANCE SERVICE
A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include [three] [six] [nine] [12] months' full maintenance by DDC system manufacturer's authorized service representative. Include [monthly] [quarterly] [semiannual] [annual] preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.028 SOFTWARE SERVICE AGREEMENT
A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for [one] [two] year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within [one] [two] year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.029 DEMONSTRATION
A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.

2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.

b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.

c. Velocity: Up to 6000 fpm.

d. Temperature: Minus 40 to plus 185 deg F.

e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.

2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.

3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, extruded aluminum.

2) Parallel or opposed blade configuration as required by application.

3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.

4) Width not to exceed 6 inches.

5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.

2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:
1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
1) Concealed in frame.
2) Constructed of aluminum and plated[or stainless steel.
3) Hardware: Stainless steel.

g. Transition:
1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:
1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

3. Airflow Measurement:
   a. Where indicated, provide damper assembly with integral airflow monitoring.
   b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
   c. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.
   d. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
   e. Suitable for operation in untreated and unfiltered air.
   f. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
   g. Provide automatic zeroing feature.

4. Airflow Control:
   a. Where indicated, provide damper assembly with integral airflow measurement and control.
   b. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
   c. The controller and actuator shall communicate to control the desired airflow.
   d. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.
   e. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.
   f. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.
   g. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.
   h. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
   i. Provide screw terminals for interface to field wiring.
   j. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

C. Rectangular Dampers with Steel Airfoil Blades:
   1. Performance:
      a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
      b. Pressure Drop: 0.06-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
      c. Velocity: Up to 6000 fpm.
      d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:
   a. Frame:
      1) Material: ASTM A653/A653M galvanized-steel profiles, 0.06 inch thick.
      2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch.
      3) Width not less than 5 inches.
   b. Blades:
      1) Hollow, airfoil, galvanized steel.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM A653/A653M galvanized steel, 0.05 inch thick.
      4) Width not to exceed 6 inches.
      5) Length as required by close-off pressure, not to exceed 48 inches.
   c. Seals:
      1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
      2) Jambs: Stainless steel, compression type.
   d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.
   e. Bearings:
      1) Stainless steel mounted in frame.
      2) Where blade axles are installed in vertical position, provide thrust bearings.
   f. Linkage:
      1) Concealed in frame.
      2) Constructed of aluminum and plated or stainless steel.
      3) Hardware: Stainless steel.
   g. Transition:
      1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
      2) Factory mount damper in a sleeve with a close transition to mate to field connection.
      3) Damper size and sleeve shall be connection size plus 2 inches.
      4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
      5) Sleeve material shall match adjacent duct.
   h. Additional Corrosion Protection for Corrosive Environments:
      1) Provide epoxy finish for surfaces in contact with airstream.
      2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Rectangular Dampers with Aluminum Flat Blades:
   1. Performance:
      a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. against 1-in. wg differential static pressure.
      b. Pressure Drop: 0.07-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
      c. Velocity: Up to 2000 fpm.
      d. Temperature: Minus 50 to plus 250 deg F.
      e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 3-in. wg.
      f. Damper shall have AMCA seal for both air leakage and air performance.
   2. Construction:
      a. Frame:
         1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
         2) Hat-shaped channel with integral flanges.
         3) Width not less than 5 inches.
      b. Blades:
         1) Flat blades of extruded aluminum.
         2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:
   1) Blades: Replaceable, mechanically attached extruded silicone, vinyl or plastic composite.
   2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:
   1) Molded-synthetic sleeve, mounted in frame.
   2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
   1) Concealed in frame.
   2) Constructed of plated or stainless steel.
   3) Hardware: Stainless steel.

g. Transition:
   1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
   2) Factory mount damper in a sleeve with a close transition to mate to field connection.
   3) Damper size and sleeve shall be connection size plus 2 inches.
   4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
   5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:
   1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
   2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

E. Rectangular Dampers with Steel Flat Blades:
1. Performance:
   a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 1500 fpm.
   d. Temperature: Minus 25 to plus 180 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.
   f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:
   a. Frame:
      1) Material: Galvanized or stainless steel, 0.06 inch thick.
      2) Hat-shaped channel with integral flanges.
      3) Width not less than 5 inches.
   b. Blades:
      1) Flat blades with multiple grooves positioned axially for reinforcement.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: Galvanized or stainless steel, 0.06 inch thick.
      4) Width not to exceed 6 inches.
      5) Length as required by close-off pressure, not to exceed 48 inches.
   c. Seals:
      1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
      2) Jambs: Stainless steel, compression type.
   d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.
   e. Bearings:
      1) Molded-synthetic sleeve, mounted in frame.
      2) Where blade axles are installed in vertical position, provide thrust bearings.
2.02 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions:[ See Drawings.] [As indicated below:]
   1. Exhaust Air: [Close] [Last position] [Open].
   2. Outdoor Air: [Close] [Last position] [Open].
   3. Supply Air: [Close] [Last position] [Open].
   4. Return Air: [Close] [Last position] [Open].
   5. <Insert system and fail position>.

2.03 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:
   1. [See Drawings] [Voltage selection is delegated to professional designing control system] [24 V] [120 V]
   2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
   3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:
   1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.

D. Field Adjustment:
1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.

2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:
   1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
   2. Control Input Signal:
      a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
      b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for [zero- to 10-] [or] [2- to 10-]V dc [and] [4- to 20-mA] signals.
      c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
      d. Programmable Multi-Function:
         1) Control input, position feedback, and running time shall be factory or field programmable.
         2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
         3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:
   1. [Equip] [Where indicated, equip] two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of [open] [and] [close] position.
   2. [Equip] [Where indicated, equip] modulating actuators with a position feedback through [current] [or] [voltage] signal for remote monitoring.
   3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:
   1. Where indicated, provide actuator to fail to an end position.
   2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
   3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:
   1. Provide against overload throughout the entire operating range in both directions.
   2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:
   1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
   2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
   3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:
   1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from [5 to 95] percent relative humidity, non-condensing.

L. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:
1. Operate damper from fully closed to fully open within [15] [60] [75] [90] [150] seconds.
2. Operate damper from fully open to fully closed within [15] [60] [75] [90] [150] seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.01 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:
B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
1. Rectangular Exhaust Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with steel airfoil blades].
2. Round Exhaust Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with steel airfoil blades].
3. Rectangular Outdoor Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with aluminum flat blades].
4. Round Outdoor Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with steel airfoil blades].
5. Rectangular Return Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with steel airfoil blades].
6. Round Return Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with aluminum flat blades].
7. Rectangular Supply Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with steel airfoil blades].
8. Round Supply Air Duct Applications with SMACNA Construction Class <Insert value> and Velocities to <Insert value>: [Rectangular dampers with aluminum airfoil blades] [Rectangular dampers with aluminum flat blades].

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.
B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a \(<\text{Insert valve}\>\) force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:
   1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:
   1. Use products that are suitable for environment to which they will be subjected.
   2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
      a. Laboratory exhaust airstreams.
      b. Process exhaust airstreams.
   3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
   4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers.

C. Furnish and install power wiring.

D. Furnish and install raceways.

3.04 CONTROL DAMPERS

A. Install smooth transitions, not exceeding [15] [30] degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:
   1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
   2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:
   1. Dampers and actuators shall be accessible for visual inspection and service.
   2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator.
D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system.

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.

I. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.05 CHECKOUT PROCEDURES

A. Control-Damper Checkout:
   1. Check installed products before continuity tests, leak tests, and calibration.
   2. Check dampers for proper location and accessibility.
   3. Verify that control dampers are installed correctly for flow direction.
   4. Verify that proper blade alignment, either parallel or opposed, has been provided.
   5. Verify that damper frame attachment is properly secured and sealed.
   6. Verify that damper actuator and linkage attachment are secure.
   7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
   8. Verify that damper blade travel is unobstructed.

3.06 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer’s recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION
SECTION 23 0923.14
FLOW INSTRUMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Airflow measurement stations and sensors.
   2. Airflow switches.
   3. Airflow transmitters.
   4. Liquid flow meters.
   5. Liquid flow sensors.
   7. Liquid flow transmitters.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of [10] [20] percent above Project design flow and [10] [20] percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters shall have an extended range of [10] [20] percent above Project design flow and [10] [20] percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

C. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.02 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:
   1. Adjustable for changes in system operational parameters.
   3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
      a. Product certificates are required.

B. Thermal Airflow Measurement Stations:
   1. Common Performance Requirements:
      a. Provide stations that are adjustable for changes in system operational parameters.
      b. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
c. Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.


e. Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.

f. Sensor-Node and Probe Assemblies:
   1) Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are unacceptable.

   2) Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.

   3) Sensing-Node Temperature Accuracy: Within 0.15 deg F over an operating range of minus 20 to plus 160 deg F and humidity range of 0 to 100 percent RH.

   4) Sensor-Probe Mounting Bracket Construction: Type 304 stainless steel.

   5) Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.

   6) Internal Probe Wiring Connections: Solder joints and spot welds, sealed and protected from the elements, so that direct exposure to water will not affect instrument operation. Connectors within the probe, of any type, are unacceptable. Printed circuit boards within the probe are unacceptable.

   7) Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F, and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.

   8) Sensor-Probe Cable Connector Plug: Gold-plated pins for connection to the transmitter.

   g. Transmitter Features and Functions:
   1) High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.

   2) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.

   3) Alarm delay function, field defined.

   4) Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.

   5) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.

   6) Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.

   7) Operating temperature range of minus 20 to plus 120 deg F and humidity range of 5 to 95 percent RH.

   8) Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.

   9) Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.

   10) Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.


   12) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).

2. For Air-Ducted/Plenum:
   a. Airflow Station Performance:
1) Independent processing of up to 16 separately wired sensor-node assemblies.

2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:
1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.

2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
   a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm.
   b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Provide the number of independent sensor nodes as follows:
   a) For Duct/Plenum Area up to 0.5 sq. ft.: One.
   b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft.: Two.
   c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft.: Six.
   d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft.: Eight.
   e) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft.: 12.
   f) For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft.: 14.
   g) For Duct/Plenum Area Greater Than 14.0 sq. ft.: 16.

4) For an aspect ratio of 1.5 or less, and an area of 25 sq. ft. or greater, four probes are required.

5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:
1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
   a) Model GTC116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

   b) Model GTM116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm,
system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

3. For Air-Ducted/Plenum - Duct Size 2 sq. ft. or Less:

a. Airflow Station Performance:
   1) Independent processing of up to four separately wired sensor-node assemblies.
   2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:
   1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
   2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
      a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm.
      b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
   3) Provide the number of independent sensor nodes as follows:
      a) For Duct/Plenum Area up to 0.5 sq. ft.: One.
      b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft.: Two.
      c) For Duct/Plenum Area Greater Than 1.0 sq. ft.: Four.

4) For probes less than 8 inches

5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:
   1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
   2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP, or Modbus RTU) field-selectable network connection.
   3) Model HTA104 Transmitter, Analog Capability: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
   4) Model HTAN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

4. For Supply or Return Fan Array:

a. Airflow Station Performance:
1) Independent processing of up to eight separately wired sensor-node assemblies.

2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:
1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
   a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
   b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

4) Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

c. Transmitter:
1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.

2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
   a) Model GTC108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

   b) Model GTM108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters,
airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

5. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Both Analog and Network Outputs:

   a. Airflow Station Performance:
      1) Independent processing of up to eight separately wired sensor-node assemblies.
      2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

   b. Sensor-Node and Probe Assemblies:
      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
      4) Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.

   c. Transmitter:
      1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
      2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
         a) Model GTC108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
         b) Model GTM108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or...
low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL108 Transmitter Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

6. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Either Analog or Network Outputs:

   a. Airflow Station Performance:

      1) Independent processing of up to four separately wired sensor-node assemblies.

      2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

   b. Sensor-Node and Probe Assemblies:

      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).

         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

   c. Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

   d. Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.

   e. Transmitter:

      1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

      2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

      3) Model HTA104 Transmitter, Analog Capability: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.

      4) Model HTN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

7. For Air Terminal Units:

8. Airflow Station Performance:
a. Independent processing of up to two separately wired sensor-node assemblies.

b. **Accuracy:** Within 3 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

9. **Sensor-Node and Probe Assemblies:**
   a. **Sensor-Node Calibration:**
      1) Individually calibrated at a minimum of seven calibration points to NIST-traceable volumetric standards from 0 to 3000 fpm (0 to 15.2 m/s).
      2) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
   b. Provide the number of independent sensor nodes as follows:
      1) For a Duct Diameter of 4 inches (102 mm): One.
      2) For Duct Diameters 5 through 16 inches (127 through 406 mm): Two.
   c. **Sensor-Probe Construction:** Mill-finish, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

10. **Transmitter:**
   a. Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
   b. **User Interface:** An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
   c. **Model EF-A Transmitter, Analog Capability:** Two field-selectable [0- to 5-V dc, ] [1- to 5-V dc, ] [0- to 10-V dc,] [or] [2- to 10-V dc,] scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
   d. **Model EF-N Transmitter, Network Communications:** The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
   e. **Contact Closure Relay:** One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

11. **For Packaged HVAC Units, 12.5 Tons (44.0 kW) or Smaller:**
   a. **Airflow Station Performance:**
      1) Independent processing of up to two separately wired sensor-node assemblies.
      2) **Accuracy:** Within 10 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.
   b. **Sensor-Node and Probe Assemblies:**
      1) **Sensor-Node Internal Wiring Connections:** Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
      2) **Sensor-Node Calibration:**
         a) Individually calibrated at a minimum of seven calibration points to NIST-traceable airflow standards from 0 to 3000 fpm (0 to 15.2 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Provide the number of independent sensor nodes as follows:
         a) For a Duct Diameter of 4 inches (102 mm): One.
         b) For Duct Diameters 5 through 16 inches (127 through 406 mm): Two.
      4) **Sensor-Probe Construction:** Mill-finish, 6063 aluminum alloy tube, with each sensor probe containing one or more independently wired sensing nodes.
   c. **Transmitter:**
1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.

2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

3) Model EF-A Transmitter, Analog Capability: Two field-selectable [0- to 5-V dc.] [1- to 5-V dc.] [0- to 10-V dc.] [or] [2- to 10-V dc.] scalable and protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature low and/or high airflow set-point (user-defined) or system status alarm.

4) Model EF-N Transmitter, Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection to provide average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

12. For Directional Airflow:
   a. Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
   b. Bi-directional airflow, or equivalent differential pressure data, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routine.
   c. Sensor-Node Calibration:
      1) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 3000 to plus 3000 fpm(minus 15.2 to plus 15.2 m/s).
      2) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F(minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter.
   d. Transmitter:
      1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
      2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
      3) Model EF-A Transmitter, Analog Capability: Two field-selectable [0- to 5-V dc.] [1- to 5-V dc.] [0- to 10-V dc.] [or] [2- to 10-V dc.] scalable and protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature low and/or high airflow set-point (user-defined) or system status alarm.
      4) Model EF-N Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
      5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

13. For Data Center Server Rack Airflow/Pressure and Temperature Monitor:
   a. Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
   b. Bi-directional airflow, or equivalent differential pressure data, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routines.
   c. Sensor-Node and Probe Assemblies:
1) Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.

2) Sensor-Node Calibration:
   a) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 2000 to plus 2000 fpm (minus 10.2 to plus 10.2 m/s).
   b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

d) Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F (minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter. Plenum-rated PVC jacket cables are unacceptable.

e) Transmitter:
   1) Integral Transmitter with Display: Mounted internally to the rack enclosure an integral, minimum 16-character LCD display capable of simultaneously displaying airflow and temperature, and capable of displaying individual airflow and temperature readings.
   2) Transmitter Interface: Four-button interface for field configuration and diagnostics.
   3) Power Supply: On-off power switch, 110 V ac at 8 VA, fused and protected from overvoltage, overcurrent, and power surges. Provide dual independent and redundant power supplies.
   4) Network Interface: One isolated Ethernet network connection (simultaneously supporting field-selectable BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP protocols).

14. For Combination Control Damper and Airflow Station - Equal Area Method Distribution Pattern:
   a. Thermal airflow station and integral damper with two or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor-node distribution pattern to be based on equal area method.
   b. Airflow Station Performance:
      1) Independent processing of up to 16 separately wired sensor-node assemblies.
      2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.
   c. Sensor-Node and Probe Assemblies:
      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Provide the number of independent sensor nodes as follows:
         a) For Damper Area up to 1.0 sq. ft. (0.092 sq. m): Two.
         b) For Duct/Plenum Area Greater Than 1.0 through 4.0 sq. ft. (0.092 through 0.372 sq. m): Four.
         c) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Six.
         d) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): Eight.
         e) For Duct/Plenum Area Greater Than 12.0 through 16.0 sq. ft. (1.11 through 1.49 sq. m): 12.
         f) For Duct/Plenum Area Greater Than 16.0 sq. ft. (1.49 sq. m): 16.
4) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube with each sensor probe containing one or more independently wired sensing nodes.

d. Transmitter:
   1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
   2) User Interface: 16-character, alpha-numeric, LCD display, with two field selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
      a) Model GTC116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
      b) Model GTM116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
      c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.
      d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Control Damper and Sleeve:
   1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.
      a) Thickness: Not less than 0.080-inch(2.0-mm) thickness for each damper section.
      b) Sleeve Depth: 15 inches (381 mm) for ducted applications and 18-inches(457 mm) for non-ducted applications including damper frame. Non-ducted applications include a 3-inch-(7.6-mm-) radius, aluminum entry flair.
      c) Installation: Provide an additional 7 inches(178 mm) for non-ducted, 10 inches(254 mm) for ducted, applications between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louver.
      d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft.(15.2 L/s per sq. m) of face area against 1-inch wg(248.8-Pa) differential static pressure.
2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch(1.52-mm) thickness.
   a) Blade Seals: Extruded EPDM.
   b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.
   c) Orientation: Parallel or opposed blade configuration as required by application.
3) Bearings: Celcon inner bearing fixed to a 7/16-inch(11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.
5) Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested.

15. For Combination Control Damper and Airflow Station - Modified Log Distribution Pattern:
   a. Thermal airflow station and integral damper with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor node distribution pattern to be based on modified log Tchebycheff method.
   b. Airflow Station Performance:
      1) Independent processing of up to 16 separately wired sensor-node assemblies.
      2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.
   c. Sensor-Node and Probe Assemblies:
      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Provide the number of independent sensor nodes as follows:
         a) For Damper Area up to 1.0 sq. ft.(0.092 sq. m): Two.
         b) For Duct/Plenum Area Greater Than 1.0 through 2.0 sq. ft.(0.092 through 0.185 sq. m): Four.
         c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft.(0.185 through 0.372 sq. m): Six.
         d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft.(0.372 through 0.743 sq. m): Eight.
         e) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft.(0.743 through 1.11 sq. m): 12.
         f) For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft.(1.11 through 1.30 sq. m): 14.
         g) For Duct/Plenum Area Greater Than 14.0 sq. ft.(1.49 sq. m): 16.
   d. Transmitter:
      1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
      2) User Interface: 16-character, alpha-numeric, LCD display, with two field selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
         a) Model GTC116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output
signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

b) Model GTM116 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Control Damper and Sleeve:

1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.
   a) Thickness: Not less than 0.080-inch (2.0-mm) thickness for each damper section.
   b) Sleeve Depth: 13 inches (330 mm) for all applications including damper frame. Sleeve includes a 1-inch (2.56-mm-) radius, aluminum entry flair.
   c) Installation: Provide an additional 7 inches (178 mm) between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louters.
   d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.
   a) Blade Seals: Extruded EPDM.
   b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.
   c) Orientation: Parallel or opposed blade configuration as required by application.

3) Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.
5) Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested.

16. For Combination Backdraft Damper and Airflow Station:
   a. Thermal airflow station with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
   b. Airflow Station Performance:
      1) Independent processing of up to eight separately wired sensor-node assemblies.
      2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.
   c. Sensor-Node and Probe Assemblies:
      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
      4) Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.
   d. Transmitter:
      1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
      2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
         a) Model GTC108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
         b) Model GTM108 Transmitter: Two field-selectable [0- to 5-V dc,] [0- to 10-V dc,] [or] [4- to 20-mA,] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth
low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Heavy-Duty Backdraft Damper:

1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.
   a) Thickness and Depth: Not less than 0.080-inch (2.0-mm) thickness.
   b) Sleeve Depth: 8 inches (457 mm), which act as an integrated sleeve. Optional 1-inch (7.6-mm) radius, aluminum entry flair.
   c) Installation: Provide an additional 7 inches (178 mm) between the downstream edge of any components and leading edge of the damper frame or entry flare.
   d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.
   a) Blade Seals: Extruded EPDM.
   b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.
   c) Orientation: Parallel configuration as required by application.

3) Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

C. Pitot-Tube Airflow Sensor Station:

1. Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.
   a. Stations 4 sq. ft. and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. of station area.
   b. Stations Larger than 4 sq. ft.: One total-pressure sensor and one static-pressure sensor for every 36 sq. in. of station area.

2. Casing: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A653/A653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
   a. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.
   b. Casing Depth: At least 8 inches.
   c. Casing Flanges: Outward flange, minimum flange face 1.5 inches.
   d. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.

3. Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
   a. Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless steel casings.

4. Construct pressure sensor array from drawn copper or stainless steel tubing. Use stainless steel for units with stainless steel casings. Copper tubing shall comply with ASTM B75 and ASTM B280. Minimum tube wall thickness shall be 0.030 inch. Include internal piping and external pressure transmitter ports.
5. Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.

6. Performance:
   a. Pressure Loss: 0.015-inch wg at 1000 fpm, or 0.085-inch wg at 2000 fpm.
   b. Accuracy: Within 2 percent of actual airflow.
   c. Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.
   d. Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.

D. Pitot-Tube Fan Inlet Airflow Traverse Sensor:
   1. Traverse manifold designed for mounting in fan inlets.
   2. Contain multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the manifold nor be adversely affected by particle contamination present in airstream.
   3. Manifold (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.
   4. Sensors shall be capable of producing steady, non-pulsating signals of standard total- and static-pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a turndown range of 6 to 1.
   5. Manifold Materials: Copper or anodized aluminum or Type 316 stainless steel.
   6. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter copper and aluminum manifolds shall be the following:
      a. For Fan Inlets Smaller Than 20 Inches: 0.375 inch.
      b. For Fan Inlets 20 Inches and Larger: 0.75 inch.
   7. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter stainless steel manifolds shall be the following:
      a. For Fan Inlets Smaller Than 20 Inches: 0.375 inch.
      b. For Fan Inlets 20 through 48 Inches: 0.75 inch.
      c. For Fan Inlets Larger Than 48 Inches: 1.0 inch.

E. Piezometer Ring Fan Inlet Airflow Sensor:
   1. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.
   2. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
   3. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
   4. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
   5. Sensor shall be non-intrusive and not impact fan performance.
   6. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

2.03 AIRFLOW SWITCHES

A. Polymer Film Sail Switch:
   1. Performance:
      a. Suitable for applications operating at velocities up to 400 fpm.
      b. Suitable for mounting with air direction in horizontal, vertical up or down.
      c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
      d. Voltage: 24-, 120-, 240-V ac.
      e. Normally Open Full Load Current: 2 A at 120-V ac.
      f. Normally Closed Full Load Current: 1 A at 120-V ac.
      g. Normally open switch actuates at 250 fpm and opens at 75 fpm.
      h. Normally closed switch actuates at 75 fpm and closes at 250 fpm.
      i. Maximum Process Temperature: 170 deg F.
      j. Maximum Ambient Temperature: 125 deg F.
2. Construction:
   a. Polyester film sail encasing a wire frame.
   b. Sail actuates a SPDT snap switch.
   d. Enclosure with removable cover.
   e. NEMA 250, Type 1 enclosure.
   f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
   g. Electrical Connections: Screw terminals.
   h. Conduit Connections: 1/2-inch trade size conduit knock outs on top and bottom.

B. Stainless Steel Single Vane Switch:
   1. Description:
      a. Velocities up to 2000 fpm.
      b. Suitable for mounting with air direction in horizontal.
   2. Performance:
      a. Voltage: 125-, 240-, and 480-V ac.
      b. Full Load Current: 9.8 A at 125-V ac.
      c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
      d. Maximum Process Temperature: 180 deg F.
      e. Maximum Ambient Temperature: 125 deg F.
   3. Construction:
      a. Stainless steel vane.
      b. Vane actuates a SPDT snap switch.
      d. Enclosure with removable cover.
      e. NEMA 250, Type 1 enclosure.
      f. Screw set-point adjustment.
      g. Electrical Connections: Screw terminals.
      h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

2.04 AIRFLOW TRANSMITTERS

A. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:
   1. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
   2. NEMA 250, Type 1 enclosure.
   3. Construct assembly so shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
   4. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
   5. Performance:
      a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
      b. Calibrated Span: Field adjustable, minus 40 percent of the range.
      c. Accuracy: Within 0.25 percent of natural span.
      d. Repeatability: Within 0.15 percent of calibrated span.
      e. Linearity: Within 0.2 percent of calibrated span.
      f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
   6. Integral digital display for continuous indication of airflow.

B. Pressure Differential Transmitters for Airflow Measurement:
   1. Performance:
      a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
      b. Accuracy: Within [1] [0.5] [0.4] [0.25] percent of the full-scale range.
      c. Hysteresis: Within 0.10 percent of full scale.
d. Repeatability: Within 0.05 percent of full scale.

2. Output Signals:
   a. Analog Current Signal:
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.
   b. Analog Voltage Signal:
      1) Three wire, zero to 5 V.
      2) Minimum Load Resistance: 1000 ohms.

3. Display: Four-digit digital with minimum 0.4-inch- high numeric characters.

4. Operator Interface:
   a. Zero and span adjustments located behind cover.

5. Construction:
   a. Plastic casing with removable plastic cover.
   b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.

2.05 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:
1. Adjustable for changes in system operational parameters.
2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Insertion Paddle Wheel Flow Meter, NPS 1:
1. Description:
   a. Insertion-type meter with a non-magnetic spinning paddle wheel.
   b. Each meter shall be wet calibrated at factory to standards traceable to NIST and provided with a certificate of calibration.
   c. Programming kit including cable connector and Microsoft-Windows-compatible software.
   d. Where indicated, provide meter with bi-directional flow measurement.

2. Performance:
   a. Range: 0.33 to 20 fps.
   b. Accuracy: Within [0.5] percent of flow rate.
   c. Repeatability: Within 0.5 percent.
   d. Ambient Temperature: 14 to 150 deg F.
   e. Maximum Process Temperature: 300 deg F with PEEK sensor tip.
   f. Maximum Pressure: 350 psig at 300 deg F with PEEK sensor tip.
   g. Pressure Drop: Up to 0.5 psig at 10 fps for pipe sizes NPS 1-1/2 and larger.

3. Output Signal:
   b. Unidirectional Flow Meter: Analog, two wire, loop-powered, 4- to 20-mA signal.
   d. Bi-directional Flow Meter: Analog 4- to 20-mA signal plus direction.

4. Operator Interface:
a. Programming: Instrument programming through computer and programming kit.
b. Digital Display: Eight-character digital display of flow rate, flow totalization, input, output, and flow direction for bi-directional meters.

5. Construction:
   a. Wetted Metal Parts (Including Sensor Stem, Mounting Adapter, and Isolation Valve):
      Type 316 stainless steel.
   b. Sensor Tip: PPS or PEEK.
   c. Shaft: Tungsten carbide.
   d. Impeller: Stainless steel.
   f. Instrument Isolation Valve: Full port ball valve for system isolation.
   g. Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.
   h. Electronics Enclosure:
      1) Polypropylene with Viton-sealed acrylic cover.
      2) Removable cover.
      3) NEMA 250, Type 4X.
      4) Electrical Connection: Screw terminals.
      5) Conduit Connection: 1/2-inch trade size.

C. Insertion Turbine Flow Meter:
1. Description:
   a. Operating pressure of 300 psig with a temperature of 200 deg F.
   b. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
   c. Pressure drop not to exceed 1 psig at 20-fps flow velocity in a NPS 2 pipe and decreasing in large pipe with lower velocity.
   d. Sensor Accuracy:
      1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps.
      2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps.
      3) Within 0.5 percent of actual reading at the calibrated velocity.
   e. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.
2. Sensor:
   a. For Pipe Sizes NPS 2 and Smaller: Single turbine sensors.
   b. For Pipe Sizes NPS 2-1/2 and Larger: Dual turbine sensors.
   c. Piping with Bi-directional Flow: Bi-directional dual turbine sensors.
   d. Dual turbine sensors shall have dual, contra-rotating turbine elements, each turbine element with its own rotational sensing system, and an averaging circuit.
   e. Rotational sensing of each turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
   f. Sensor shall have an integral frequency output linear with flow rate. For dual turbine units, with individual top and bottom turbine outputs for diagnostic purposes.
   g. Bi-directional sensors shall have isolated solid-state dry contacts with a contact rating of 100 mA at 50 V. The contacts shall close when the flow in direction of arrow is 0.18 fps or more.
   h. Flow sensor shall be complete with installation hardware necessary to enable insertion and removal from pipe without system shutdown.
   i. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including installation hardware.
   j. House sensor electronics in a NEMA 250, Type 4 enclosure.
   k. Enclosure shall include connection(s) for field-installed conduit.
   l. Sensor shall have cable of length sufficient to connect to display module.
   m. Sensor housing shall have full port Type 316 stainless steel ball valve for system isolation.
3. Display Module:
   a. Remote from sensor.
   b. House in a NEMA 250, Type 4X enclosure.
   c. Label terminal strip for all wiring connections.
   d. 120-V ac power supply with 24-V dc output to power the flow sensor.
e. Remote Interface:
   1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
   2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
   3) Outputs linear to within 0.1 percent of calibrated span.

f. Digital display for flow rate and totalized flow:
   1) At least eight display digits for totalization.
   2) Bi-directional units with separate digital display for flow and totalization in each direction.

g. Local reset of flow totalization.

h. Program and data shall be stored in nonvolatile memory in event of power loss.

i. For bi-directional units, with display of flow direction (contacts open or closed).

D. Inline Turbine Flow Meter:
   1. Description:
      b. Operating pressure of 300 psig with a temperature of 200 deg F.
      c. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
      d. Pressure drop not to exceed 3 psig at 38 gpm.
      e. Sensor Accuracy:
         1) Within 2 percent of actual flow between the flow range of 0.8 to 38 gpm.
         2) Within 0.5 percent of actual reading at the calibrated velocity.
      f. Wet calibrate and tag sensors to standards traceable to NIST and provide each sensor with a certificate of calibration.

   2. Sensor:
      a. Rotational sensing of turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
      b. Sensor shall have an integral frequency output linear with flow rate.
      c. Sensor shall have threaded union on each end.
      d. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
      e. Construct wetted metal components of brass or stainless steel.
      f. House sensor electronics in a NEMA 250, Type 4 enclosure.
      g. Enclosure shall include connection(s) for field-installed conduit.
      h. Sensor shall have cable of length sufficient to connect to display module.

   3. Display Module:
      a. Remote from sensor.
      b. Enclosure: NEMA 250, Type 4X.
      c. Label terminal strip for all wiring connections.
      d. 120-V ac power supply with 24-V dc output to power the flow sensor.
      e. Remote Interface:
         1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
         2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
         3) Outputs linear to within 0.1 percent of calibrated span.
      f. Digital display of flow rate and totalized flow.
      g. At least eight display digits for totalization.
      h. Local reset of flow totalization.
      i. Program and data shall be stored in nonvolatile memory in the event of power loss.

2.06 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

A. Venturis:
   1. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
   2. Standard: ASME MFC-3M.
3. Performance:
   a. Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.
   b. Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.
   c. Size and beta ratio shall be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.

4. Construction:
   a. One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2.
   b. One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8, and fabricated steel with flanged connections for larger sizes.
   c. Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.
   d. Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.
   e. Use venturi with pressure differential transmitter.

B. Orifice Plates:
   1. Standards: ASME MFC-3M or ASME MFC-14M.
   2. Performance:
      a. Orifice plates shall be sharp, square-edged concentric type.
      b. Shop fabricate and calibrate orifice meter runs through NPS 2.
      c. Field fabricate orifice runs NPS 3 and larger.
      d. Meter run piping or tubing shall be uniform internal surface, which is free of internal grooves and striations, but is not polished. Out of roundness shall not exceed 0.5 percent. A reduction of the pipe diameter or distortion caused by welding is unacceptable.
      e. Size orifice plates for 100-inch wg pressure differential, except that the absolute value of the meter range shall not exceed the absolute value of the flowing pressure.
      f. Ratio of orifice diameter to actual internal pipe diameter d/B (beta) shall be between 0.70 and 0.30.
      g. Locate orifice plates in horizontal or vertical lines in accordance with good metering practice.
      h. Minimum upstream and downstream straight pipe shall comply with ASME Fluid Meters Research Committee Reports.
   3. Construction:
      a. Fabricate the orifice plate and matching companion flanges of Type 316 stainless steel.
      b. Transmitter connection shall be at least NPS 1/2.
      c. Stamp the orifice plates with the number and the orifice bore on the handle of the plate.
   4. Use orifice plate with pressure differential transmitter.
   5. Calibration information and calculations shall comply with either of the referenced standards for each orifice plate.

C. Portable Meter Package for Liquid Flow Sensors:
   1. Metal-reinforced-plastic carrying case.
   2. Waterproof meter with nominal 6-inch round dial face.
   4. Meter with external range and zero adjustment.
   5. Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.
   6. Two connecting hoses, [10-feet] <Insert dimension> long, with quick connect couplings compatible with venturi couplings.
   7. Two brass blowdown valves with Buna-N seals and blowdown hoses.
   9. Suitable for working pressure of 200 psig at 200 deg F.
   10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.
   11. Turn over to Owner at Project completion.
2.07 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

1. Description:
   a. Field-adjustable four-vane combinations.
   b. Field-adjustable set-point adjustment screw.
   c. Suitable for pipe sizes NPS 1 through NPS 8.
   d. Switch mounted vertically in horizontal pipe.

2. Performance:
   a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
   c. Temperature Limit: 230 deg F.
   d. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
   e. Switch Type: SPDT snap switch.

3. Wetted Parts Construction:
   b. Vanes: Stainless steel.
   c. Body: Forged brass.

4. Enclosure:
   a. Die-cast aluminum alloy.
   b. NEMA 250, Type 4.
   c. Electrical Connection: Cable gland with attached wire leads.

B. Liquid Flow Switch (Magnetic Type):

1. Description:
   a. Field-adjustable five-vane combinations.
   b. Suitable for pipe sizes NPS 1-1/2 through NPS 20.
   c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

2. Performance:
   a. Flow Rate Actuation and De-actuation: Varies with vane combination.
   b. Pressure Limit: 1000 psig for brass body, 2000 psig for Type 316 stainless steel body.
   c. Temperature Range: Minus 4 to plus 275 deg F.
   d. Electrical Rating: 10 A at 125/250-V ac.
   e. Switch Type: [SPDT] [DPDT] snap switch.

3. Wetted Parts Construction:
   a. Vanes: Type 316 stainless steel.
   b. Body: Brass or Type 316 stainless steel.
   c. Magnetic Keeper: Type 430 stainless steel or Type 316 stainless steel.

4. Enclosure:
   a. Die-cast aluminum alloy.
   b. Threaded cover.
   c. NEMA 250, Type 4.
   d. Electrical Connection: Terminal block.
   e. Conduit Connection: 3/4-inch trade size.

2.08 LIQUID FLOW TRANSMITTERS

A. Liquid Pressure Differential Transmitter for Flow Measurement:

1. Performance:
   a. Range: Approximately 2 times the set point.
   b. Span: Adjustable plus or minus 1 mA, non-interactive.
   c. Accuracy: Within 0.25 percent of full scale.
d. Maximum Operating Pressure: 2.5 times range.
e. Temperature Limits: Zero to 175 deg F.
f. Compensate Temperature Limits: 30 to 150 deg F.
g. Thermal Effects: 0.02 percent of full scale per degree F.
h. Response Time: 30 to 50 ms.
i. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:
   a. Two wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.

3. Operator Interface:
   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:
   a. Aluminum and stainless steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.
   c. NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch trade size conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting bracket shall be suitable for installation.

5. Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 process connections.

PART 3 - EXECUTION

3.01 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Thermal Airflow Measurement Stations:
   1. For Air-Ducted/Plenum:
      a. Measured Velocities Greater Than 200 fpm
      b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
   2. For Air-Ducted/Plenum - Duct Size 2 sq. ft.or Less:
      a.Measured Velocities Less Than 200 fpm
   3. For Supply or Return Fan Array:
      a. Measured Velocities Greater Than 200 fpm
   4. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans:
      a. Measured Velocities Greater Than 200 fpm
   5. For Air Terminal Units:
      a. Measured Velocities Greater Than 200 fpm
   6. For Packaged HVAC Units, 12.5 Tons or Smaller:
      a. Measured Velocities Greater Than 200 fpm
   7. For Directional Airflow Sensors:
      a. Measured Velocities Greater Than 50 fpm: Thermal airflow measurement station.
      b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.
   8. For Data Center Server Rack Airflow/Pressure and Temperature Monitor:
      a. Measured Velocities Greater Than 200 fpm
9. For Damper-Mounted Airflow Stations:
   a. Measured Velocities Greater Than 200 fpm

C. Duct-Mounted Airflow Sensors:
   2. Measured Velocities Greater than 500 fpm: [Pitot-tube airflow sensor station] [Thermal airflow station].

D. Damper-Mounted Airflow Sensors:
   1. Measured Velocities 400 fpm and Less: Thermal airflow station.
   2. Measured Velocities Greater than 500 fpm: [Pitot-tube airflow sensor station] [Thermal airflow station].

E. Fan-Mounted Airflow Sensors:

F. Airflow Switches:

G. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:
   1. Exhaust Air Airflow: [Airflow transmitter with 0.25 percent accuracy and auto-zero feature] [Pressure differential transmitter for airflow measurement].
   2. Outdoor Air Airflow: [Airflow transmitter with 0.25 percent accuracy and auto-zero feature] [Pressure differential transmitter for airflow measurement].
   3. Return Air Airflow: [Airflow transmitter with 0.25 percent accuracy and auto-zero feature] [Pressure differential transmitter for airflow measurement].
   4. Supply Air Airflow: [Airflow transmitter with 0.25 percent accuracy and auto-zero feature] [Pressure differential transmitter for airflow measurement].

H. Liquid Flow Sensors (Primary Elements):
   1. [Venturis] [Orifice plates].

I. Liquid Flow Meters:
   1. [Insertion paddle wheel transmitter] [Turbine flow meter] [Electromagnetic flow meter].

J. Liquid Flow Switches:
   1. [Bellows type] [Magnetic type].

K. Liquid Flow Transmitters:
   1. Liquid pressure differential transmitter.

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
F. Corrosive Environments:
1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRIC POWER
A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers.
C. Furnish and install power wiring.
D. Furnish and install raceways.

3.04 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS
A. Mounting Location:
   1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
   2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
   3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
B. Mounting Height:
   1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
   2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
      a. Make every effort to mount at 60 inches.
C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.05 FLOW INSTRUMENTS INSTALLATION
A. Airflow Sensors:
1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.

2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.

2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.

3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.

4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.

2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.

3. Install in-line meters with flanges or unions to provide drop-in and -out installation.

4. Insertion Meters:
   a. Install system process connections full size of meter connection, but not less than [NPS 1] [NPS 1-1/2] [NPS 2] . Provide stainless steel bushing if required to mate to system connection.

   b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

   c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than [NPS 1] [NPS 1-1/2] [NPS 2] . Install stainless steel bushing if required to mate switch to system connection.

2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.

2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.07 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.

2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:
1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

END OF SECTION
SECTION 23 0923.16
GAS INSTRUMENTS

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes the Following Gas Instruments:
   2. VOC sensors and transmitters.

1.02 DEFINITIONS
A. NDIR: Nondispersive infrared.

1.03 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 CARBON-DIOXIDE SENSORS AND TRANSMITTERS
A. Description:
   1. NDIR technology or equivalent technology providing long-term stability and reliability.
   2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.
B. Construction:
   1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
   2. Equip with digital display for continuous indication of carbon-dioxide concentration.
C. Performance:
   2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
   3. Repeatability: Within 1 percent of full scale.
   4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
   5. Long-Term Stability: Within 5 percent of full scale after more than five years.
   6. Response Time: Within 60 seconds.
   7. Warm-up Time: Within five minutes.
D. Provide calibration kit. Turn over to Owner at start of warranty period.

2.02 VOC SENSORS AND TRANSMITTERS
A. Description:
   1. VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.
   2. Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.
C. Performance:
   1. Measurement Range: Zero to 100 percent.
   2. Ambient Temperature: 32 to 140 deg F.
   3. Ambient Relative Humidity: 5 to 95 percent non-condensing.
PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:
      a. Laboratory exhaust airstreams.
      b. Process exhaust airstreams.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.02 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers.

C. Furnish and install power wiring.

D. Furnish and install raceways.

3.03 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:
   1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
   2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of [2] [3] percent.

B. Mounting Height:
1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
   a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.04 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.05 CHECKOUT PROCEDURES
A. Check out installed products before continuity tests, leak tests, and calibration.
B. Check instruments for proper location and accessibility.
C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section includes moisture switches, sensors, and transmitters.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 MOISTURE SWITCHES
A. Humidistat for Duct Applications:
   1. Description:
      a. Two-position control.
      b. Field-adjustable set point.
      c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Performance:
      a. Relative Humidity Range: 15 to 95 percent.
      b. Relative Humidity Differential: 5 percent.
      c. Ambient Temperature: 40 to 135 deg F.
      d. Voltage: 120-V ac.
      e. Current: 7.2 FLA.
      f. Switch Type: SPDT snap switch.
   3. Construction:
      a. Enclosure: Metal, NEMA 250, Type 1.
      b. Electrical Connections: Screw terminals.

B. Humidistat for Space Applications:
   1. Description:
      a. Two-position control.
      b. Field-adjustable set point.
      c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Performance:
      a. Relative Humidity Range: 10 to 90 percent.
      b. Relative Humidity Differential: 5 percent.
      c. Ambient Temperature: 40 to 135 deg F.
      d. Voltage: 24-V ac.
      e. Pilot Duty: 60 VA.
      f. Switch Type: SPDT snap switch.
   3. Construction:
      a. Enclosure: Plastic, NEMA 250, Type 1.
      b. Electrical Connections: Cable, 6 inches long.
2.02 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Performance:
   a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.
   b. Relative Humidity Range: Zero to 100 percent.
   c. Factory calibrated and NIST traceable with certificate included.

2. Construction:
   a. Provide housing with integral sensor for room applications.
   b. Provide housing with remote sensor probe for ducted applications.
      1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.
      2) Provide sensor with cable for field installation in conduit.
      3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.
   c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
   d. Housing shall be ABS/PC plastic or powder-coated aluminum.
   e. Housing Classification: NEMA 250, Type 4 or 4X.
   f. Provide housing with wall-mounting plate.

3. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.

4. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Performance:
   a. Relative Humidity Range: Zero to 100 percent.
   c. Operating Temperatures: Minus 30 to 130 deg F.
   d. Hysteresis: Within 1 percent.

2. Construction:
   a. Duct-type sensor for duct-mounted applications. Integral-type sensor for room or space applications.
   b. Sensor Body: 300 series stainless steel, 6 inches long for duct-mounted applications.
   c. For outdoor and duct applications, install circuitry in a NEMA 250, Type 4 or 4X enclosure.

3. Output Signal:
   a. Two-wire, 4- to 20-mA output signal with a drive capacity of at least 600 ohms at 24-V dc.
   b. Non-interacting zero and span adjustments.

PART 3 - EXECUTION

3.01 MOISTURE INSTRUMENT APPLICATIONS

A. [Sensor and transmitter with digital display] [Sensor and transmitter without display] [Combination humidity and temperature sensor and transmitter with display].

3.02 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

C. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers.

C. Furnish and install power wiring.

D. Furnish and install raceways.

3.04 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:
   1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
   2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
      a. Make every effort to mount at 60 inches.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.

B. Install engraved phenolic nameplate with instrument identification on face of ceiling directly below instruments concealed above ceilings.

3.06 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:
1. Insertion length shall be at [4 inches] [6 inches] [8 inches] [12 inches].
2. Sensor with four radial holes of 0.04-inch diameter.
3. [Brass] [or] [stainless-steel] construction.
4. Sensor with threaded end support, sealing washers and nuts.
6. Suitable for flat oval, rectangular, and round duct configurations.

B. Outdoor Static Pressure Sensor:
1. Provides average outdoor pressure signal.
2. Sensor with no moving parts.
3. Kit includes sensor, vinyl tubing mounting hardware.

C. Space Static Pressure Sensor for Wall Mounting:
1. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
2. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with brass barbed fitting for tubing connection.

D. Space Static Pressure Sensor for Recessed Ceiling Mounting:
1. [Aluminum] [Stainless-steel] round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360 degree radial source.
2.02 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:
   1. Diaphragm operated to actuate an SPDT snap switch.
   2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
   3. Enclosure Conduit Connection: Knock out or threaded connection.
   4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
   6. Enclosure:
      a. Dry Indoor Installations: NEMA 250, Type 1.
      b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
      c. Hazardous Environments: Explosion proof.
   7. Operating Data:
      a. Electrical Rating: 15 A at 120- to 480-V ac.
      b. Pressure Limits:
         1) Continuous: 45 inches wg.
         2) Surge: 10 psig.
      c. Temperature Limits: Minus 30 to 180 deg F.
      d. Operating Range: Approximately 2 times set point.
      e. Repeatability: Within 3 percent.
      f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:
   1. Performance:
      a. Range: Approximately 2 times set point.
      b. Accuracy: Within [0.25] [0.5] percent of the span at reference temperature of 70 deg F.
      c. Hysteresis: Within 0.02 percent of the span.
      d. Repeatability: Within 0.05 percent of the calibrated span.
      e. Stability: Within 0.25 percent of span per year.
      f. Overpressure: 15 psig.
      g. Temperature Limits: Minus 20 to 160 deg F.
      h. Compensate Temperature Limits: 35 to 135 deg F.
      i. Thermal Effects: 0.015 percent of full scale per degree F.
      j. Warm-up Time: Within 5 seconds.
      k. Response Time: [5 ms] [250 ms] [One second].
      l. Shock and vibration shall not harm the transmitter.
   2. Output Signals:
      a. Analog Current Signal:
         1) Two-wire, 4- to 20-mA dc current source.
         2) Signal capable of operating into 1000-ohm load.
      b. Analog Voltage Signal:
         2) Minimum Load Resistance: 1000 ohms.
   3. Operator Interface:
      a. Zero and span adjustments within 10 percent of full span.
      b. Potentiometer adjustments located on face of transmitter.
   4. Construction:
      a. Type 300 stainless-steel enclosure.
      b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
      c. Screw terminal block for wire connections.
      d. Vertical plane mounting.
      e. NEMA 250, Type 2.
      f. Mounting Bracket: Appropriate for installation.
g. Reverse wiring protected.
h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

B. Air-Pressure Differential Indicating Transmitter:

1. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F.
   c. Stability: Within 1 percent of full scale per year.
   d. Overpressure: 10 psig.
   e. Temperature Limits: 20 to 120 deg F.
   f. Thermal Effects: 0.055 percent of full scale per degree F.

2. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.

3. Operator Interface:
   a. Zero and span adjustments.
   b. Selectable engineering units.

4. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 1200-ohm load.

5. Construction:
   a. Plastic casing with clear plastic cover.
   b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
   c. Terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 1.
   f. Nominal 4-inch diameter face.
   g. Mounting Bracket: Appropriate for installation.

2.04 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

1. Description:
   a. Diaphragm operated to actuate an SPDT snap switch.
   b. Electrical Connections: Screw terminal.
   c. Enclosure Conduit Connection: Knock out or threaded connection.
   d. User Interface: External screw with visual set-point adjustment.
   f. Enclosure:
      1) Dry Indoor Installations: NEMA 250, Type 1.
      2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
      3) Hazardous Environments: Explosion proof.

2. Operating Data:
   a. Electrical Rating: 15 A at 120-V ac.
   b. Pressure Limits:
      1) Range 1 to 30 psig: 60 psig.
      2) Range 10 to 125 psig: 160 psig.
   c. Temperature Limits: Minus 30 to 150 deg F.
   d. Operating Range: [1 to 30 psig] [10 to 250 psig].
   e. Deadband: Fixed.

3. Pressure Chamber Material: [Steel] [or] [Stainless steel].

4. Diaphragm Material: [Nylon] [or] [PTFE].

B. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Description:
   a. [Brass] [or] [Type 316 stainless steel] double opposing bellows operate to actuate a SPDT snap switch.
   b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
f. Enclosure:
   1) Dry Indoor Installations: NEMA 250, Type 1.
   2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   3) Hazardous Environments: Explosion proof.
g. Operating Data:
   1) Electrical Rating: 15 A at 120- to 240-V ac.
   2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
   3) Temperature Limits: Minus 10 to 180 deg F.
   4) Operating Range: Approximately 2 times set point.
   5) Deadband: [Adjustable] [Fixed] [Adjustable or fixed as required by application].

2.05 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:
   1. Performance:
      a. Range: Approximately 2 times set point.
      b. Span: Adjustable plus or minus one milliamp, noninteractive.
      c. Accuracy: Within 0.25 percent of full scale.
      d. Pressure: Maximum operating pressure 2.5 times range.
      e. Temperature Limits: Zero to 175 deg F.
      f. Compensate Temperature Limits: 30 to 150 deg F.
      g. Thermal Effects: 0.02 percent of full scale per degree F.
      h. Response Time: 30 to 50 ms.
      i. Shock and vibration shall not harm the transmitter.
   2. Analog Output Current Signal:
      a. Two-wire, 4- to 20-mA dc current source.
      b. Signal capable of operating into 1000-ohm load.
   3. Operator Interface:
      a. Zero and span adjustments located behind cover.
      b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
   4. Construction:
      a. Aluminum and stainless-steel enclosure with removable cover.
      b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
      c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
      d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
      e. Screw terminal block for wire connections.
      f. NEMA 250, Type 4X.
      g. Mounting Bracket: Appropriate for installation.
   5. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 process connections.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a <Insert value> force.
C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.02 ELECTRICAL POWER
A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers.
C. Furnish and install power wiring.
D. Furnish and install raceways.

3.03 PRESSURE INSTRUMENT INSTALLATION
A. Mounting Location:
1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of $\frac{2}{3}$ percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of $\frac{2}{3}$ percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
C. Duct Pressure Sensors:
1. Install sensors using manufacturer’s recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately [50] [67] [75] percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer’s instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:
1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:
1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than [NPS 1/2] [NPS 3/4] [NPS 1]. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:
1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than [NPS 1/2] [NPS 3/4] [NPS 1]. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.04 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.
B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.05 CHECKOUT PROCEDURES
A. Check out installed products before continuity tests, leak tests, and calibration.
B. Check instruments for proper location and accessibility.
C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section includes speed switches for direct-digital controls for HVAC.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 ROTATIONAL SPEED SWITCHES
A. Rotational Speed Switch (Non-Contact Type):
   1. Description:
      a. Speed switch, sensor, and electronics housed in enclosure.
      b. Shaft-end-mounted disc, or split collar wrap generates an alternating magnetic field sensed by the switch.
      c. Dust, dirt, and grease proof.
      d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.
   2. Performance:
      a. Field-Adjustable Range: [10 to 100] [100 to 5000] rpm.
      b. Temperature Limits: Minus 40 to 140 deg F.
      c. Electrical Rating: 5 A at 115-V ac.
      d. Switch Type: SPDT.
      e. Gap Distance: Approximately 0.375 inch.
   4. Enclosure Construction:
      a. [PVC] [Cast aluminum].
      b. Removable cover.
      c. NEMA 250, Type 4X.
      d. Electrical Connection: Wiring, 12 inches long, furnished with switch.
      e. Conduit Connection: 1-inch trade size.
   5. Disc, Guard, and Mounting Bracket Construction:
      a. Magnetic Disc: Nylon or PVC.
      b. Disc Guard: Stainless steel.
      c. Mounting Bracket: Aluminum with stainless-steel shaft.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL
A. Install products level, plumb, parallel, and perpendicular with building construction.
B. Properly support speed-switch wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.
C. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.02 ELECTRIC POWER
A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers.
C. Furnish and install power wiring.
D. Furnish and install raceways.

3.03 SPEED-SWITCH INSTALLATIONS
A. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.04 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection.
B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Air temperature sensors.
2. Air temperature switches.
3. Air temperature RTD transmitters.
4. Liquid and steam temperature sensors.
5. High-end, commercial-grade, liquid and steam temperature sensors.
7. High-end, commercial-grade, liquid and steam temperature transmitters.

1.02 ACTION SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.01 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:
1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
   a. Range: Minus 50 to 275 deg F.
   b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
   c. Repeatability: Within 0.5 deg F.
4. Transmitter Requirements:
   a. Transmitter required for each 100-ohm RTD.
   b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:
1. [100] or [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:
1. [100] or [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:
1. [100] or [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.

E. Platinum RTD Space Air Temperature Sensors:
1. [100] or [1000] ohms.
2. Temperature Range: Minus 50 to 212 deg F
3. Probe assembly shall include a temperature sensing element mounted under a [bright white, non-yellowing, plastic] [flush, brushed aluminum] cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:
1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
   a. Range: Minus 50 to 275 deg F.
   b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
   c. Repeatability: Within 0.5 deg F.
   d. Drift: Within 0.5 deg F over 10 years.
   e. Self-Heating: Negligible.
4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:
1. Temperature Range: Minus 50 to 275 deg F
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch trade size

H. Thermistor Averaging Air Temperature Sensors:
1. Temperature Range: Minus 50 to 275 deg F
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size

I. Thermistor Outdoor Air Temperature Sensors:
1. **Temperature Range:** Minus 50 to 275 deg F
2. **Probe:** Single-point sensor with a stainless-steel sheath.
3. **Solar Shield:** Stainless steel.
4. **Enclosure:** NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. **Conduit Connection:** 1/2-inch trade size.

### J. Thermistor Space Air Temperature Sensors:
1. **Temperature Range:** Minus 50 to 212 deg F
2. **Sensor assembly** shall include a temperature sensing element mounted under a [bright white, non-yellowing, plastic] [flush, brushed aluminum] cover.
3. **Provide a mounting plate** that is compatible with the surface shape that it is mounted to and electrical box used.
4. **Concealed wiring connection.**

### K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:
1. **[100-] [or] [1000-] ohm platinum RTD [or thermistor].**
   a. **Thermistor:**
      b. **Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.**
      b. **Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.**
3. **Temperature Transmitter Requirements:**
   a. **Mating transmitter required with each 100-ohm RTD.**
   b. **Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.**
4. **Provide digital display of sensed temperature.**
5. **Provide sensor with local control.**
   a. Local override to turn HVAC on.
   b. Local adjustment of temperature set point.
   c. Both features shall be capable of manual override through control system operator.

### 2.02 AIR TEMPERATURE SWITCHES

#### A. Thermostat and Switch for Low Temperature Control in Duct Applications:
1. **Description:**
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. **Performance:**
   a. Operating Temperature Range: 15 to 55 deg F.
   b. Temperature Differential: 5 deg F, non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
   d. Sensing Element Maximum Temperature: 250 deg F.
   e. Voltage: 120-V ac.
   f. Current: 16 FLA.
   g. **Switch Type:** Two SPDT snap switches operate on coldest 12-inch section along element length.
3. **Construction:**
   a. Vapor-Filled Sensing Element: Nominal 20 feet long.
   b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 1/2-inch trade size.

#### B. Thermostat and Switch for High Temperature Control in Duct Applications:
1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

2. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:
   a. Temperature Range: 100 to 160 deg F.
   b. Temperature Differential: 5 deg F.
   c. Ambient Temperature: Zero to 260 deg F.
   d. Voltage: 120-V ac.
   e. Current: 16 FLA.
   f. Switch Type: SPDT snap switch.

4. Construction:
   b. Enclosure: Metal, NEMA 250, Type 1.
   c. Electrical Connections: Screw terminals.
   d. Conduit Connection: 1/2-inch trade size.

2.03 AIR TEMPERATURE RTD TRANSMITTERS

A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

B. House electronics in NEMA 250 enclosure.
   1. Duct: [Type 1] [Type 2] [Type 3].
   2. Outdoor: [Type 4] [or] [Type 4X].
   3. Space: Type 1.

C. Conduit Connection: 1/2-inch

D. Functional Characteristics:
   1. Input:
      a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
      b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
   2. Span (Adjustable):
      a. Space: 40 to 90 deg F.
      b. Supply Air Cooling and Heating: 40 to 120 deg F.
      c. Supply Air Cooling Only: 40 to 90 deg F.
      d. Supply Air Heating Only: 40 to 120 deg F.
      e. Exhaust Air: 50 to 100 deg F.
      f. Return Air: 50 to 100 deg F.
      g. Mixed Air: Minus 40 to 140 deg F.
      h. Outdoor: Minus 40 to 140 deg F.
   3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
   4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
   5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:
   1. Calibration Accuracy: Within 0.1 percent of the span.
   2. Stability: Within 0.2 percent of the span for at least 6 months.
   3. Combined Accuracy: Within 0.5 percent.
2.04 LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:
1. Description:
   a. Platinum with a value of [100] [or] [1000] ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
   b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.
   c. Sensor Length: 4, 6, or 8 inches as required by application.
   d. Process Connection: Threaded, NPS 1/2
   e. Two-stranded copper lead wires.
   f. Powder-coated steel enclosure, NEMA 250, Type 4.
   g. Conduit Connection: 1/2-inch
   h. Performance Characteristics:
      1) Range: Minus 40 to 210 deg F.
      2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:
1. Stem: [Straight] [or] [stepped] shank formed from solid bar stock.
2. Material: [Brass] [or] [stainless steel].
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inches as required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.05 LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

A. RTD:
1. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.
2. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch OD.
4. Provide [two] [three] [four]-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
5. Provide spring-loaded RTDs for thermowell installations.
6. Performance Characteristics:
   a. Range: Minus 328 to 932 deg F.
   b. Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.
   c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.
   d. Hysteresis: Within 0.04 percent of range.
   e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

B. Thermowells:
1. Stem: [Straight] [or] [stepped] [or] [tapered] shank formed from solid bar stock.
2. Material: [Type 304] [or] [Type 316] stainless steel.
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
7. Length: As required by application and pipe size.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads:
1. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
2. Terminals: Six or eight as required by sensor.
3. Conduit Connection: 1/2-inch trade size.

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.06 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:
1. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:
   a. Operating Temperature Range: 65 to 200 deg F.
   b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
   c. Enclosure Ambient Temperature: 150 deg F.
   e. Voltage: 120-V ac.
   f. Current: 8 FLA.
   g. Switch Type: SPDT snap switch.

3. Construction:
   a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
   b. Temperature Scale: Fahrenheit, visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 3/4-inch.

2.07 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. House electronics in NEMA 250, [Type 4] [or] [Type 4X] enclosure.

B. Enclosure Connection: 1/2-inch trade size.

C. Functional Characteristics:
   1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, [two-] [or] [three-wire sensors].
   2. Default Span (Adjustable):
      a. Chilled Water: Zero to 100 deg F.
      b. Condenser Water: Zero to 120 deg F.
      c. Heating Hot Water: 32 to 212 deg F.
      d. Heat Recovery: Zero to 120 deg F.
      e. <Insert system and span>.
   3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
   4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
   5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:
   1. Calibration Accuracy: Within 0.1 percent of the span.
   2. Stability: Within 0.2 percent of the span for at least 6 months.
   3. Combined Accuracy: Within 0.5 percent.
PART 3 - EXECUTION

3.01 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:
   1. Duct, <Insert application>: [Thermistor] [100-ohm platinum RTD] [1000-ohm platinum RTD].
   2. Outdoor, <Insert application>: [Thermistor] [100-ohm platinum RTD] [1000-ohm platinum RTD].
   3. Space, <Insert application>: [Thermistor] [100-ohm platinum RTD] [1000-ohm platinum RTD].

B. Air Temperature Transmitters:
   1. Duct, <Insert application>: [Not required] [Air temperature RTD transmitter].
   2. Outdoor, <Insert application>: [Not required] [Air temperature RTD transmitter].
   3. Space, <Insert application>: [Not required] [Air temperature RTD transmitter].

C. Liquid and Steam Temperature Sensors:
   1. <Insert system> System, <Insert unique application>: [Liquid and steam temperature sensor, commercial grade] [Liquid and steam temperature sensor, high-end commercial grade].

D. Liquid and Steam Temperature Transmitters:
   1. <Insert system> System, <Insert unique application>: [Liquid and steam temperature transmitter, commercial grade].

3.02 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

C. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers.

C. Furnish and install power wiring.

D. Furnish and install raceways.
3.04 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:
   1. Roughing In:
      a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
      b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
         1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
         2) Do not begin installation without submittal approval of mounting location.
      c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
   2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
   3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:
   1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
   2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:
   1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
   2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
      a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:
   1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
   2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
   3. In finished areas, recess electrical box within wall.
   4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
   5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
F. Outdoor Air Temperature Sensor Installation:
   1. Mount sensor in a discrete location facing north.
   2. Protect installed sensor from solar radiation and other influences that could impact performance.
   3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:
   1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
   2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
   3. Rigidly support sensor to duct and seal penetration airtight.
   4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:
   1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
   2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
   3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
   4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:
   1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
   2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
   3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
   4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:
   1. Assembly shall include sensor, thermowell and connection head.
   2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
   3. For pipe smaller than NPS 4:
      a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
      b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
      c. Minimum insertion depth shall be 2-1/2 inches.
   4. Install matching thermowell.
   5. Fill thermowell with heat-transfer fluid before inserting sensor.
   6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor service platform or catwalk.

3.05 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.
B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.06 CLEANING
A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
B. Wash and shine glazing.
C. Polish glossy surfaces to a clean shine.

3.07 CHECK-OUT PROCEDURES
A. Check installed products before continuity tests, leak tests, and calibration.
B. Check temperature instruments for proper location and accessibility.
C. Verify sensing element type and proper material.
D. Verify location and length.
E. Verify that wiring is correct and secure.

3.08 FIELD QUALITY CONTROL
A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform according to manufacturer's written instruction.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
B. Prepare test and inspection reports.

3.09 ADJUSTING
A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes mechanical vibration switches connected to direct digital control systems for HVAC.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 MECHANICAL VIBRATION SWITCHES

A. Description: Inertia-sensitive armature mechanism trips on high vibration and operates snap action switch.

B. Performance:
   1. Frequency Range: Zero to 3600 rpm.
   3. Temperature Limits: Minus 40 to 158 deg F.
   4. Electrical Rating: 15 A at 125- or 480-V ac.
   5. Switch Type: [SPDT] [DPDT] snap switch.
   6. Start Delay: 20 to 30 seconds, by applying reset voltage at start signal to prevent switch from tripping.

C. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Groups B, C, and D; Class II, Groups E, F, and G.

D. Operator Interface:
   1. Vibration Set-Point Adjustment: Zero to 100 percent of range.
   2. Push-button reset on switch face and reset coil for remote reset.

E. Enclosure Construction:
   1. Cast aluminum.
   2. NEMA 250, [Type 4] [or] [Type 4X].
   3. Electrical Connection: Screw terminals.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

C. Properly support instrument wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

D. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.02 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers.

C. Furnish and install power wiring.

D. Furnish and install raceways.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection.

B. Install engraved phenolic nameplate with instrument identification.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

1.02 HEATING CONTROL SEQUENCES

A. Indicate the following on the operator's workstation display terminal:
   1. DDC system graphic.
   2. DDC system status, on-off.
   3. Outdoor-air temperature.
   4. Room temperature.
   5. Circulating pump(s) on-off status (enabled or disabled).
   6. Circulating pump(s) on-off indication (operating or not operating).
   7. Additional circulating pump(s) pressure differential.
   8. Additional circulating pump(s) pressure differential set point.
   9. Additional circulating pump(s) on-off indication (operating or not operating).
  10. Circulating pump(s) alarm pressure differential.
  11. Circulating pump(s) alarm pressure differential set point.
  12. Alarm (circulating pump(s) failure).
  13. Circulating pump(s) speed pressure differential.
  14. Circulating pump(s) speed pressure differential set point.
  15. Circulating pump(s) speed.
  17. Heating-water return temperature.
  19. Heating-water supply temperature set point.
  20. Heating-water control-point output valve.

1.03 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Air-Handling Unit Occupied Time Schedule:
   1. Enable startup, initiation, and control.
   2. Energize unit on occupied/unoccupied cycle.
   3. Energize unit on day/night cycle.
   4. Energize unit on duty cycle.
   5. Energize return-air fans 30 seconds after supply fans are energized.
   6. Do not enable mixed-air control during morning warm-up period.
      a. Unoccupied: Position outdoor-air and relief-air dampers closed and return-air dampers open.
   7. Do not enable humidifier control during morning warm-up period.
   8. Enable control of heating coil(s) during morning warm-up period.
   9. Energize coil circulating pump(s).
  10. Return heating control valves to normal position when unit is cycled on.
  11. Do not enable cooling-coil control during morning warm-up period.
B. Start and Stop Supply Fan(s):
   1. Allow start if temperature is above 37 deg F.
   2. Signal alarm if fan fails to start as commanded.

C. Start and Stop Supply Fan(s):
   1. Allow start if temperature is below 120 deg F.
   2. Signal alarm if fan fails to start as commanded.

D. Start and Stop Supply Fan(s):
   1. Allow start if airstream is free of products of combustion.
   2. Signal alarm if fan fails to start as commanded.

E. Supply Fan(s) Variable-Volume Control:
   1. Fan Speed Control:
      a. Maintain constant supply-duct static-pressure set point of <Insert value>.
      b. Set-Point Reset (for Systems with DDC of Individual Zone Terminals): Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
      c. Set variable-frequency drive to minimum speed when fan is stopped.
   3. High Pressure: When static pressure rises above excessive-static-pressure set point of <Insert value>:
      a. Stop fan.
      b. Signal alarm.

F. Return Fan(s) Variable-Volume Control:
   1. Maintain constant airflow offset between supply- and return-air fans.
   2. Set variable-frequency drive to minimum speed when fan is stopped.

G. Return Fan(s) Variable-Volume Control:
   1. Maintain constant indoor static-pressure set point of 0.02-inch wg positive for outdoors.
   2. Set variable-frequency drive to minimum speed when fan is stopped.

H. Preheat Coil:
   1. Freeze Protection: Allow air-handling unit start if duct temperature is above 33 deg F.
   2. Low-Temperature Operation: Energize coil circulating pump(s) at outdoor-air temperatures below [5 deg F.
   3. [Supply] [Discharge]-Air Temperature: Maintain air-temperature set point of 55 deg F.

I. Mixed-Air Control:
   1. Minimum Position:
      a. Open [minimum outdoor-air dampers] [outdoor-air dampers to minimum position].
      b. Modulate outdoor-air dampers to maintain minimum airflow at set point of <Insert value>.
   2. Heating Reset: [Close minimum outdoor-air dampers] [Set outdoor-air dampers to minimum position].
   3. Carbon Dioxide Reset: Reset minimum outdoor-air damper position to maintain carbon dioxide set point of <Insert value>.
   4. [Supply] [Mixed]-Air Temperature:
      a. Modulate outdoor-, return-, and relief-air dampers to maintain air-temperature set point of 55 deg F.
      b. Do not enable control during morning warm-up period.
   5. Cooling Reset: Set outdoor-air dampers to minimum position when outdoor-air [temperature exceeds return-air temperature] [enthalpy exceeds return-air enthalpy].

J. Filters: Signal alarm on [low- and ]high-pressure differential conditions.

K. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
L. Indicate the following on the operator's workstation display terminal:
   1. DDC system graphic.
   2. DDC system on-off indication (operating or not operating).
   3. DDC system occupied/unoccupied mode.
   5. Supply-fan on-off indication (operating or not operating).
   7. Supply duct static-pressure set point.
  10. Return-fan on-off indication (operating or not operating).
  11. Space static-pressure indication.
  12. Space static-pressure set point.
  15. Preheat-coil air-temperature indication.
  17. Preheat-coil pump on-off indication (operating or not operating).
  18. Preheat-coil control-valve position.
  22. Relative humidity indication.
  23. Relative humidity set point.
  25. Filter air-pressure-drop indication.
  26. Filter low-air-pressure drop set point.
  27. Filter high-air-pressure drop set point.
  28. [Supply] [Discharge]-air-temperature indication.
  29. [Supply] [Discharge]-air-temperature set point.
  31. Heating-coil leaving-air-temperature set point.
  32. Heating-coil pump on-off indication (operating or not operating).
  33. Heating-coil control-valve position.
  34. Cooling-coil leaving-air-temperature indication.
  35. Cooling-coil leaving-air-temperature set point.
  36. Cooling-coil control-valve position.
  37. Space temperature indication.
  38. Space temperature set point.

1.04 TERMINAL UNIT OPERATING SEQUENCE

A. Unit Heater, Electric: Space thermostat cycles fan and sequences stages of heating to maintain 75 deg F space temperature.

B. Combustion-Air Unit Heaters: Modulate valve to maintain 75 deg F space temperature.

C. Radiant Heating Panel, Electric: Cycle power to maintain space temperature set points.
   1. Occupied: 75 deg F.
   2. Unoccupied: 65 deg F.

D. Heating Coils, Electric: Sequence stages of heating to maintain 75 deg F space temperature.

E. Radiators and Convectors, Electric: Sequence stages of heating to maintain 75 deg F space temperature set point.

F. Constant-Volume, Terminal Air Units, Hydronic:

2. Space Temperature: Modulate valve to maintain space temperature set points.
   a. Occupied Cooling Temperature: 75 deg F
   b. Occupied Heating Temperature: 70 deg F.
   c. Unoccupied Cooling Temperature: 85 deg F.
   d. Unoccupied Heating Temperature: 65 deg F.

G. Sequence Control:
   1. Space Temperature: Modulate valves and dampers to maintain space temperature set points.
      a. Occupied Cooling Temperature: 75 deg F.
      b. Occupied Heating Temperature: 70 deg F.
      c. Unoccupied Cooling Temperature: 85 deg F.
      d. Unoccupied Heating Temperature: 65 deg F.
      e. Modulate damper actuator from open to minimum position.
      f. When damper is at minimum position, modulate finned-tube radiation valve from closed to fully open.
      g. When finned-tube radiation valve is fully open, modulate reheat coil valve from closed to fully open.
      h. If occupied space temperature is not maintained with both valves open, modulate damper actuator from minimum position to 100 percent open.
      i. Reverse the sequence for full heating to full cooling.

H. Indicate the following on the operator's workstation display terminal:
   1. DDC system graphic.
   2. DDC system on-off indication (operating or not operating).
   3. DDC system occupied/unoccupied mode.
   5. Cabinet Unit Heater, Hydronic:
      a. Space temperature indication.
      b. Space temperature set point.
      c. Fan on.
   6. Unit Heater, Hydronic:
      a. Space temperature indication.
      b. Space temperature set point.
      c. Fan on.
   7. Combustion-Air Unit Heaters:
      a. Space temperature indication.
      b. Space temperature set point.
      c. Control-valve position.
   8. Sequence Control:
      a. Space/area served.
      b. Space occupied/unoccupied.
      c. Space temperature indication.
      d. Space temperature set point, occupied.
      e. Space temperature set point, unoccupied.
      f. Damper position as percentage open.
      g. Control-valve positions as percentage open.

1.05 VENTILATION SEQUENCES

A. Combustion-Air, Makeup Unit Control, Electric:
   1. Initiation: Start fan when appliance burner starts.
   2. Space Temperature: Sequence electric coil stages to maintain 75 deg F space temperature.

B. Gravity Roof Ventilator: Open control damper when space [is occupied] [temperature rises above set point].
C. Exhaust Fan with [occupancy sensor] [light switch] [room thermostat]: Cycle fan on when [space is occupied] [lights are turned on] [space temperature rises above set point].

D. Kitchen Exhaust Fan with Occupancy Sensor: Start fan and energize makeup air unit when space is occupied.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   5. Pressure regulators.
   6. Dielectric unions.

1.02 ACTION SUBMITTALS

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

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

1.03 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 QUALITY ASSURANCE

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

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

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

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.02 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   4. Corrugated stainless-steel tubing with polymer coating.
   5. Operating-Pressure Rating: 0.5 psig.
   8. Maximum Length: 72 inches

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

C. Y-Pattern Strainers:
   1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

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

2.03 JOINING MATERIALS

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


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

2.04 MANUAL GAS SHUTOFF VALVES

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

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

D. Bronze Plug Valves: MSS SP-78.
2. Plug: Bronze.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.05 PRESSURE REGULATORS

A. General Requirements:
1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   2. Springs: Zinc-plated steel; interchangeable.
   7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

2.06 DIELECTRIC UNIONS

A. Dielectric Unions:
   1. Description:
      b. Pressure Rating: 150 psig.
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.01 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade.
   1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Steel Piping with Protective Coating:
   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

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

E. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

F. Paint all roof-mounted gas piping on roof yellow.

3.02 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

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

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

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

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

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

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

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage upstream and downstream from each line regulator.

V. Install sleeves for piping penetrations of walls, ceilings, and floors.

W. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

3.03 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install underground valves with valve boxes.
C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.04 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
   2. Bevel plain ends of steel pipe.
   3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.05 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

B. Connect to utility's gas main according to utility's procedures and requirements.

C. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

D. Install piping adjacent to appliances to allow service and maintenance of appliances.

E. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

F. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.
3.06 CONNECTIONS
A. Connect to utility's gas main according to utility's procedures and requirements.
B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
C. Install piping adjacent to appliances to allow service and maintenance of appliances.
D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.07 FIELD QUALITY CONTROL
A. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
B. Natural-gas piping will be considered defective if it does not pass tests and inspections.
C. Prepare test and inspection reports.

3.08 OUTDOOR PIPING SCHEDULE
A. Aboveground natural-gas piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.
   3. Annealed-temper copper tube with wrought-copper fittings and brazed joints.

3.09 INDOOR PIPING SCHEDULE
A. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

3.010 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE
A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
   1. Plug valve.
B. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION
SECTION 23 2300

REFRIGERANT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Refrigerant pipes and fittings.
   2. Refrigerant piping valves and specialties.
   3. Refrigerants.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of valve, refrigerant piping, and refrigerant piping specialty.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.05 QUALITY ASSURANCE


B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

B. Line Test Pressure for Refrigerant R-407C:
C. Line Test Pressure for Refrigerant R-410A:

2.02 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L 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/A5.8M.

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 deg 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 deg F.

B. Packed-Angle Valves:
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: Rising stem.
   5. Seal Cap: Forged-brass or valox hex cap.
   6. End Connections: Socket, union, threaded, or flanged.
   8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Maximum Opening Pressure: 0.50 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (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] [115] [208]-V ac coil.
7. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with AHRI 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 deg F.
6. Superheat: [Adjustable] [Nonadjustable].
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: [700 psig] [450 psig].

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: [Internal] [External].
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and [24] [115] [208]-V ac coil.
10. Throttling Range: Maximum 5 psig.
12. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg 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 parts per million (ppm).
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [alumina] [charcoal].
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
7. Maximum Pressure Loss: 2 psig <Insert value>.
10. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with AHRI 730.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [alumina] [charcoal].
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
10. Maximum Operating Temperature: 240 deg F.

2.04 REFRIGERANTS

A. ASHRAE 34, R-134a: Tetrafluoroethane.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.
PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines: 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. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.02 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: 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] [Type L], 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: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

F. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type L], annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

H. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

I. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.03 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.
E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.04 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. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. 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.

O. 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.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Identify refrigerant piping and valves.

R. Install sleeves for piping penetrations of walls, ceilings, and floors.

S. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

3.05 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

3.06 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints.

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 maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.07 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
      a. 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.

B. Prepare test and inspection reports.

3.08 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.

3.09 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.

E. Check open compressor-motor alignment and verify lubrication for motors and bearings. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION
SECTION 23 3113
METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

   A. Section Includes:
      1. Single-wall rectangular ducts and fittings.
      2. Single-wall round ducts and fittings.
      4. Duct liner.
      5. Sealants and gaskets.
      6. Hangers and supports.
      7. Seismic-restraint devices.

1.03 ACTION SUBMITTALS

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

   B. Product Data: For each type of the following products:
      1. Liners and adhesives.
      2. Sealants and gaskets.

   C. Shop Drawings:
      1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and
         attachments to other work.
      2. Factory- and shop-fabricated ducts and fittings.
      3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
      5. Dimensions of [main] [all] duct runs from building grid lines.
      6. Fittings.
      7. Reinforcement and spacing.
      8. Seam and joint construction.
      9. Penetrations through fire-rated and other partitions.
     10. Equipment installation based on equipment being used on Project.
     11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
     12. Hangers and supports, including methods for duct and building attachment[, seismic restraints,]
         and vibration isolation.

1.04 INFORMATIONAL SUBMITTALS

   A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described
      in this Section, and coordinated with all building trades.
B. Welding certificates.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
1. [AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.]

PART 2 - PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. Where specified for specific applications, all joints shall be welded.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
1. Where specified for specific applications, all joints shall be welded.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND AND FLAT OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: G60 or G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Factory- or Shop-Applied Antimicrobial Coating:
   1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
   2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
   4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
   5. Shop-Applied Coating Color: Black or White.
   6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
G. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.  
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. 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 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity:
      a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

   2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

   3. [Solvent] [Water]-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
      a. Adhesive shall have a VOC content of 80 g/L or less.
      b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health’s "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

   2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      a. Adhesive shall have a VOC content of 80 g/L or less.
      b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health’s "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.
   1. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C518.

   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.

   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      a. Adhesive shall have a VOC content of 80 g/L or less.
      b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health’s "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [0.106-inch-] [0.135-inch-] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel or aluminum or stainless steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.05 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: [3 inches] [4 inches] [6 inches].


5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. Sealant shall have a VOC content of 420 g/L or less.
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Sealant shall have a VOC content of 420 g/L or less.
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
12. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
13. Service: Indoor or outdoor.
14. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.
   6. Sealant shall have a VOC content of 420 g/L or less.
   7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
   8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.07 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or 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.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A603, galvanized or ASTM A492, stainless-steel cables with end connections made of galvanized-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

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

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E488/E488M.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

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. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.
   1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
   2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT

B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

C. All ducts exposed to view shall be constructed of stainless steel as per "Duct Schedule" Article. All ducts concealed from view shall be stainless or carbon steel as per "Duct Schedule" Article.

D. All joints shall be welded and shall be telescoping, bell, or flange joint as per NFPA 96.

E. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of [20] [12] feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.

F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.04 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS

A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.

B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open site floor drain.

C. Minimize number of transverse seams.

D. Do not locate longitudinal seams on bottom of duct.

3.05 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS

A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."

B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.

C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.06 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to be welded or have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
   1. Ductwork shall be Type 304 or Type 316 stainless steel.
   2. Ductwork shall be galvanized steel.
      a. If duct outer surface is uninsulated, protect outer surface with suitable paint.
   3. Where ducts have external insulation, provide weatherproof aluminum jacket.
3.07 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   2. Outdoor, Supply-Air Ducts: Seal Class A.
   3. Outdoor, Exhaust Ducts: Seal Class C.
   4. Outdoor, Return-Air Ducts: Seal Class C.
   5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
   6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
   7. Unconditioned Space, Exhaust Ducts: Seal Class C.
   8. Unconditioned Space, Return-Air Ducts: Seal Class B.
   9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
   10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
   11. Conditioned Space, Exhaust Ducts: Seal Class B.
   12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.08 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.09 SEISMIC-RESTRAINT-DEVICE INSTALLATION

1. Space lateral supports a maximum of [40] feet o.c., and longitudinal supports a maximum of [80] feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.

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

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect 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 applications and stainless-steel anchors for applications exposed to weather.

3.010 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.011 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.012 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
b. Supply Ducts with a Pressure Class of [2-] [3-] [4-] Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than [50] [100] percent of total installed duct area for each designated pressure class.

c. Return Ducts with a Pressure Class of [2-] [3-] [4-] Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than [50] [100] percent of total installed duct area for each designated pressure class.

d. Exhaust Ducts with a Pressure Class of [2-] [3-] [4-] Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than [50] [100] percent of total installed duct area for each designated pressure class.

e. Outdoor-Air Ducts with a Pressure Class of [2-] [3-] [4-] Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than [50] [100] percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.

5. Test for leaks before applying external insulation.

6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

7. Give seven days’ advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.013 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

   1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.

   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

   3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
E. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.014 STARTUP
A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.015 DUCT SCHEDULE
A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
B. Supply Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   b. Minimum SMACNA Seal Class: [A] [B] [C].
   c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].
2. Ducts Connected to Constant-Volume Air-Handling Units:
   b. Minimum SMACNA Seal Class: [A] [B].
   c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].
3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   b. Minimum SMACNA Seal Class: [A] [B].
<table>
<thead>
<tr>
<th>C. Ducts Connected to Equipment Not Listed Above:</th>
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<tbody>
<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C].</td>
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<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tr>
<th>D. Return Ducts:</th>
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<tr>
<td>1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:</td>
</tr>
<tr>
<td>a. Pressure Class: Positive or negative [1-] [2-] [3-] inch wg.</td>
</tr>
<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C].</td>
</tr>
<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tr>
<th>2. Ducts Connected to Air-Handling Units:</th>
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<tr>
<td>a. Pressure Class: Positive or negative [2-] [3-] inch wg.</td>
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<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C].</td>
</tr>
<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tr>
<th>3. Ducts Connected to Equipment Not Listed above:</th>
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<tr>
<td>a. Pressure Class: Positive or negative [2-] [3-] [4-] inch wg.</td>
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<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C].</td>
</tr>
<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tr>
<th>D. Exhaust Ducts:</th>
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<tbody>
<tr>
<td>1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:</td>
</tr>
<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C] if negative pressure, and [A] [B] [C] if positive pressure.</td>
</tr>
<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tr>
<th>2. Ducts Connected to Air-Handling Units:</th>
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<tbody>
<tr>
<td>a. Pressure Class: Positive or negative [2-] [3-] inch wg.</td>
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<tr>
<td>b. Minimum SMACNA Seal Class: [A] [B] [C] if negative pressure, and [A] [B] [C] if positive pressure.</td>
</tr>
<tr>
<td>c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].</td>
</tr>
<tr>
<td>d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].</td>
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<tbody>
<tr>
<td>a. Exposed to View: Type 304, stainless-steel sheet, [No. 4] [No. 3] finish.</td>
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<tr>
<td>b. Concealed: [Type 304, stainless-steel sheet, No. 2D finish] [Carbon-steel sheet].</td>
</tr>
<tr>
<td>c. Welded seams and joints.</td>
</tr>
<tr>
<td>d. Pressure Class: Positive or negative [2-] [3-] [4-] inch wg.</td>
</tr>
<tr>
<td>e. Airtight/watertight.</td>
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<tr>
<th>4. Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:</th>
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<tbody>
<tr>
<td>a. Type 304, stainless-steel sheet.</td>
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<tr>
<td>b. Exposed to View: [No. 4] [No. 3] finish.</td>
</tr>
<tr>
<td>c. Concealed: [No. 2D finish].</td>
</tr>
<tr>
<td>d. Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.</td>
</tr>
<tr>
<td>e. Pressure Class: Positive or negative [2-] [3-] inch wg.</td>
</tr>
<tr>
<td>f. Airtight/watertight.</td>
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<tr>
<th>5. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:</th>
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<tbody>
<tr>
<td>a. Type 304, stainless-steel sheet.</td>
</tr>
<tr>
<td>1) Exposed to View: [No. 4] [No. 3] finish.</td>
</tr>
<tr>
<td>2) Concealed: [No. 2B] [No. 2D] finish.</td>
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<tr>
<td>b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.</td>
</tr>
<tr>
<td>c. Pressure Class: Positive or negative [3-] [4-] [6-] inch wg.</td>
</tr>
</tbody>
</table>
d. [Minimum SMACNA Seal Class A] [Welded seams and joints].
e. [SMACNA Leakage Class 2.]
f. [Airtight/watertight.]
6. Ducts Connected to Equipment Not Listed above:
   a. Pressure Class: Positive or negative [2-] [3-] [4-] inch wg.
   b. Minimum SMACNA Seal Class: [A] [B] if negative pressure; A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative [1-] [2-] inch wg.
   b. Minimum SMACNA Seal Class: [A] [B] [C].
   c. SMACNA Leakage Class for Rectangular: [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [8] [16].
2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative [2-] [3-] inch wg.
   b. Minimum SMACNA Seal Class: [A] [B].
   c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].
3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative [2-] [3-] [4-] inch wg.
   b. Minimum SMACNA Seal Class: [A] [B].
   c. SMACNA Leakage Class for Rectangular: [2] [4] [8] [16].
   d. SMACNA Leakage Class for Round and Flat Oval: [2] [4] [8] [16].

F. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: [Galvanized steel] [Carbon steel coated with zinc-chromate primer]
   [Galvanized steel or carbon steel coated with zinc-chromate primer].
2. Stainless-Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: [Galvanized] [Match duct material].
3. Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

G. Liner:
1. Supply-Air Ducts: [Fibrous glass, Type I] [Flexible elastomeric] [Natural fiber], [1] [1-1/2] [2] <Insert dimension> inch(es) thick.
2. Return-Air Ducts: [Fibrous glass, Type I] [Flexible elastomeric] [Natural fiber], [1] [1-1/2] [2] <Insert dimension> inch(es) thick.
3. Exhaust-Air Ducts: [Fibrous glass, Type I] [Flexible elastomeric] [Natural fiber], [1] <Insert dimension> inch(es) thick.
4. Supply Fan Plenums: [Fibrous glass, Type II] [Flexible elastomeric] [Natural fiber], [1] [1-1/2] [2] <Insert dimension> inch(es) thick.
5. Return- and Exhaust-Fan Plenums: [Fibrous glass, Type II] [Flexible elastomeric] [Natural fiber], [2] <Insert dimension> inches thick.
6. Transfer Ducts: [Fibrous glass, Type I] [Flexible elastomeric] [Natural fiber], [1] [1-1/2] [2] <Insert dimension> inch(es) thick.

H. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 1000 fpm or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm:
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:
   1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14]  Inches and Larger in Diameter: [Standing seam] [Welded].

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION
SECTION 23 3300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Backdraft and pressure relief dampers.
   3. Control dampers.
   4. Fire dampers.
   5. Smoke dampers.
   6. Flange connectors.
   7. Turning vanes.
   8. Duct-mounted access doors.
   10. Duct accessory hardware.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 MATERIALS
A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: [G60] [G90].
   2. Exposed-Surface Finish: Mill phosphatized.
B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and <Insert finish designation> finish for exposed ducts.
C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: [1000 fpm] [1250 fpm] [2000 fpm] [3000 fpm].

C. Maximum System Pressure: [1-inch wg] [2-inch wg] [3-inch wg] [6-inch wg].

D. Frame: Hat-shaped, [0.05-inch- thick, galvanized sheet steel] [0.094-inch- thick, galvanized sheet steel] [0.063-inch- thick extruded aluminum] [0.03-inch- thick stainless steel] [0.05-inch- thick stainless steel], with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, [center pivoted,] [off-center pivoted,] [end pivoted,] maximum 6-inch width, [0.025-inch- thick, roll-formed aluminum] [0.050-inch- thick aluminum sheet] [noncombustible, tear-resistant, neoprene-coated fiberglass] with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: [Felt] [Vinyl foam] [Extruded vinyl, mechanically locked] [Neoprene, mechanically locked].

H. Blade Axles:
   1. Material: [Nonferrous metal] [Galvanized steel] [Plated steel] [Stainless steel] [Nonmetallic] [Aluminum].
   2. Diameter: 0.20 inch.

I. Tie Bars and Brackets: [Aluminum] [Galvanized steel].

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or [nylon] pivot bushings.

L. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Counterweights and spring-assist kits for vertical airflow installations.
   3. Electric actuators.
   4. Chain pulls.
   5. Screen Mounting: Front mounted in sleeve.
      a. Sleeve Thickness: 20 gauge minimum.
      b. Sleeve Length: 6 inches minimum.
   6. Screen Mounting: Rear mounted.
   7. Screen Material: Galvanized steel or Aluminum.
   8. Screen Type: Bird.
   9. 90-degree stops.
2.04 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Standard leakage rating, with linkage outside airstream.
   2. Suitable for horizontal or vertical applications.
   3. Frames:
      a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel or 0.05-inch- thick stainless steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized or Stainless-steel, 0.064 inch thick.
   5. Blade Axles: Galvanized steel or Stainless steel or Nonferrous metal.
   6. Bearings:
      a. Oil-impregnated bronze or Molded synthetic or Oil-impregnated stainless-steel sleeve or Stainless-steel sleeve.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   7. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
   1. Standard leakage rating, with linkage outside airstream.
   2. Suitable for horizontal or vertical applications.
   3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
      e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
   5. Blade Axles: Galvanized steel or Stainless steel or Nonferrous metal.
   6. Bearings:
      a. Oil-impregnated bronze or Molded synthetic or Stainless-steel sleeve.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   7. Tie Bars and Brackets: Aluminum.

C. Jackshaft:
   1. Size: [0.5-inch] [1-inch] diameter.
   2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:
   2. Include center hole to suit damper operating-rod size.
   3. Include elevated platform for insulated duct mounting.

2.05 CONTROL DAMPERS

A. Frames:
1. [Hat] [U] [Angle] shaped.
2. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
3. Mitered and welded or Interlocking, gusseted corners.

B. Blades:
1. Multiple blade with maximum blade width of [6 inches] [8 inches].
2. Parallel or Parallel- and opposed or Opposed-blade design.
3. Galvanized-steel or Stainless steel or Aluminum.
4. 0.064 inch thick single skin or 0.0747-inch-thick dual skin.
5. Blade Edging: Closed-cell neoprene or PVC.

C. Blade Axles: 1/2-inch-diameter; galvanized steel or stainless steel or nonferrous metal; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.

D. Bearings:
1. Oil-impregnated bronze or Molded synthetic or Oil-impregnated stainless-steel sleeve or Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.06 FIRE DAMPERS
A. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
C. Fire Rating: 1-1/2 and 3 hours.
D. Frame: [Curtain type with blades inside airstream] [Curtain type with blades outside airstream] [Multiple-blade type] [Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream]; fabricated with roll-formed, galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
F. Mounting Orientation: Vertical or horizontal as indicated.
G. Blades: Roll-formed, interlocking, galvanized sheet steel; gauge in accordance with UL listing.
H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
J. Heat-Responsive Device: Electric [Pneumatic], [resettable] [replaceable] link and switch package, factory installed, [165 deg F] [and] [212 deg F] rated.

2.07 SMOKE DAMPERS
1. Manufacturers offer additional features for engineered smoke-control system dampers.
B. General Requirements: Label according to UL 555S by an NRTL.
C. Smoke Detector: Integral, factory wired for single-point connection.
D. Frame: Hat-shaped, galvanized sheet steel, with [welded] [interlocking, gusseted] [or] [mechanically attached] corners[ and mounting flange]; gauge in accordance with UL listing.

E. Blades: Roll-formed, horizontal, [interlocking] [overlapping], galvanized sheet steel; gauge in accordance with UL listing.

F. Leakage: [Class I] [Class II].

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application[ with factory-furnished silicone caulking]; gauge in accordance with UL listing.

I. Damper Motors: Modulating or two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections.
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
   6. 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.
   7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:
   1. Auxiliary switches for [signaling] [fan control] [or] [position indication].
   2. [Momentary test switch] [Test and reset switches], [damper] [remote] mounted.

2.08 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.09 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: [Single] [Double] wall.

2.010 DUCT-MOUNTED ACCESS DOORS


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to [18 Inches] Square: [Two hinges] [Continuous] and two sash locks.
   c. Access Doors up to 24 by 48 Inches: [Three hinges] [Continuous] and two compression latches[ with outside and inside handles].
   d. Access Doors Larger Than 24 by 48 Inches: [Four hinges] [Continuous] and two compression latches with outside and inside handles.

B. Pressure Relief Access Door:
   1. Door and Frame Material: Galvanized sheet steel.
   2. Door: [Single wall] [Double wall with insulation fill] with metal thickness applicable for duct pressure class.
   3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
   4. Factory set at [3.0- to 8.0-inch wg] [10-inch wg].
   5. Doors close when pressures are within set-point range.
   6. Hinge: Continuous piano.
   7. Latches: Cam.
   8. Seal: Neoprene or foam rubber.

2.011 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.

C. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10-inch wg, positive or negative.
2.012 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.
B. Coatings and Adhesives: Comply with UL 181, Class 1.
C. Metal-Edged Connectors: Factory fabricated with a fabric strip [3-1/2 inches] [5-3/4 inches] wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.
E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd.
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

2.013 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 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
C. Install [backdraft] [control] dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.
E. Set dampers to fully open position before testing, adjusting, and balancing.
F. Install test holes at fan inlets and outlets and elsewhere as indicated.
G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream and downstream from turning vanes.
   9. Upstream or downstream from duct silencers.
   10. Control devices requiring inspection.
   11. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Install duct test holes where required for testing and balancing purposes.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

2.02 NON-INSULATED FLEXIBLE DUCTS
A. Non-Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.
B. Non-Insulated, Flexible Duct: 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 deg F.

2.03 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; [polyethylene] [aluminized] vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.
   4. Insulation R-Value: [Comply with ASHRAE/IES 90.1] [R4.2] [R6] [R8].

B. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; [polyethylene] [aluminized] vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 20 to plus 210 deg F.
   4. Insulation R-Value: [Comply with ASHRAE/IES 90.1] [R4.2] [R6] [R8].

2.04 FLEXIBLE DUCT CONNECTORS

A. Clamps: [Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action] [Nylon strap] in sizes 3 through 18 inches, to suit duct size.

B. Non-Clamp Connectors: [Adhesive] [Liquid adhesive plus tape] [Adhesive plus sheet metal screws].

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts[ directly or] with maximum [12-inch] lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts[ directly or] with maximum [60-inch] lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with [adhesive] [liquid adhesive plus tape] [draw bands] [adhesive plus sheet metal screws].

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:
   1. Install ducts fully extended.
   2. Do not bend ducts across sharp corners.
   3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
   4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
   5. Install flexible ducts in a direct line, without sags, twists, or turns.
H. Supporting Flexible Ducts:
1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION
SECTION 23 3600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Bypass, single-duct air terminal units.
   2. Modulating, single-duct air terminal units.
   3. Parallel, fan-powered air terminal units.
   4. Series, fan-powered air terminal units.
   5. Casing liner.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of air terminal unit.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."
2.02 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: [0.040-inch-] [0.034-inch-] thick galvanized steel, single wall.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections, size matching inlet size.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   2. Damper Position: Normally [open] [closed].

E. Attenuator Section: [0.034-inch steel] [0.032-inch aluminum] sheet.
   1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [fibrous-glass] [flexible elastomeric] duct liner.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Multioutlet Attenuator Section: With [two] [three] [four] [6-inch-] [8-inch-] [10-inch-] diameter collars, each with locking butterfly balancing damper.

G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

   1. Stage(s): [1] [2] [3].
   2. SCR controlled.
   3. Access door interlocked disconnect switch.
   4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
   5. Nickel chrome 80/20 heating elements.
   6. Airflow switch for proof of airflow.
   7. Fan interlock contacts.
   8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   10. Pneumatic-electric switches and relays.
   11. Magnetic contactor for each step of control (for three-phase coils).

I. Control devices shall be compatible with temperature controls system.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted, pneumatic type, [direct acting] [and] [reverse acting] with appropriate mounting hardware.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.
   d. Communication with temperature-control system.
10. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

J. Controls:
1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

K. Control Sequences:
1. Occupied:
   a. On a call for cooling, airflow will increase as the damper opens towards maximum setting to satisfy set point.
   b. On a call for less cooling, airflow will decrease as the damper closes towards minimum setting to satisfy set point.
   c. On a call for heating, after terminal unit has reached minimum airflow set point, electric-resistance heating coil will sequence control to satisfy set point.
2. Unoccupied:
   a. Damper closes to minimum setting.

2.03 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Minimum Thickness: [1/2 inch] [3/4 inch] [1 inch].
   a. Maximum Thermal Conductivity:
      1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. [Solvent] [Water]-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   1. Minimum Thickness: [1/2 inch] [3/4 inch].
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.04 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.
   1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports".

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.02 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." or ASCE/SEI 7. Comply with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, or an agency acceptable to authorities having jurisdiction.
F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect 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. Install heavy-duty sleeve anchors 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 applications and stainless-steel anchors for applications exposed to weather.

3.03 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.”

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

D. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

E. Comply with requirements for connecting ducts to air terminal units.

F. Make connections to air terminal units with flexible connectors.

G. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION
SECTION 23 7213
HEAT WHEEL AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.01 SUMMARY
   A. Section includes heat wheels.

1.02 ACTION SUBMITTALS
   A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
   B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS
   A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.
   B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.
   C. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS
   A. AnnexAire
   B. PoolPak

2.02 HEAT WHEELS
   A. Casing:
      1. Galvanized steel, stainless steel, or aluminum with standard factory finish.
2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.

3. Casing seals on periphery of rotor and on duct divider and purge section.

4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings with an L-10 400,000 hours. Support horizontal rotors on tapered roller bearing.

B. Rotor: Aluminum or polymer segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.

C. Rotor: Aluminum, metallic, or polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom, molecular-sieve desiccant coating.

D. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller and self-adjusting multilink belt around outside of rotor.
   1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Controls:
   1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
   2. Variable-Frequency Controller: Factory mounted and wired, permitting input of field-connected 4- to 20-mA or 1- to 10-V control signal.
   3. Variable-Frequency Controller with Exhaust-Air Sensor: Factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
   4. Variable-Frequency Controller with Exhaust- and Outdoor-Air Sensors: Factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.

2.03 SOURCE QUALITY CONTROL

A. AHRI 1060 Certification: Testing according to AHRI 1060 and listed and labeled by AHRI.

PART 3 - EXECUTION

3.01 INSTALLATION OF HEAT WHEELS

A. Examine roughing-in for electrical services to verify actual locations of connections before installation.

B. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
   1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
   2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
   3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
C. Install floor-mounted units on 4-inch- high concrete base designed to withstand, without damage to equipment, seismic force required by code.

D. Equipment Mounting:
1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

E. Install seismic restraints according to manufacturers' written instructions.

F. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

G. Install units with clearances for service and maintenance.

H. Comply with requirements for ductwork.

3.02 PIPING CONNECTIONS

A. Where installing piping adjacent to unit, allow space for service and maintenance.

B. Connect piping to units mounted on vibration isolators with flexible connectors.

C. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM B88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

D. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.

E. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring.

B. Ground equipment.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs.
   2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring.
3.05 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
SECTION 23 7343.16
OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes outdoor, semi-custom air-handling units that are factory assembled using multiple section components; including:
   1. Unit casings.
   2. Fan, drive, and motor section.
   3. Coil section.
   4. Air filtration section.
   5. Dampers.
   8. Air-to-air energy recovery units.
   9. Air blenders.
   10. Diffusers.
   11. UV-C lamp systems.
   12. Roof curbs.
   13. Intake and relief air openings.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each air-handling unit.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include unit dimensions and weight.
   4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
   5. Fans:
      a. Include certified fan-performance curves with system operating conditions indicated.
      b. Include certified fan-sound power ratings.
      c. Include fan construction and accessories.
      d. Include motor ratings, electrical characteristics, and motor accessories.
   6. Include certified coil-performance ratings with system operating conditions indicated.
   7. Include certified coil-performance ratings with system operating conditions indicated.
   8. Include dampers, including housings, linkages, and operators.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.
C. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Source quality-control reports.

F. Startup service reports.

G. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Daikin
B. Trane
C. York/Johnson Controls

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to [NRCA’s "NRCA Roofing Manual: Membrane Roof Systems.”] [AHRI Guideline B.] Install units on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

C. Unit Support: Install unit level on structural [curbs] [steel supports]. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of [curbs] [steel supports] with actual equipment provided.
   1. Comply with requirements for vibration isolation and seismic-control devices.
   2. Comply with requirements for vibration isolation devices

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
F. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

G. Connect duct to air-handling units with flexible connections.

3.02 PIPING CONNECTIONS

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

B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according.

B. Ground equipment.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs.
   2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. HEPA Filters: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
5. HEPA Filters: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:
   1. Casings.
   2. Fans, drives, and motors.
   3. Rotary heat exchangers.
   5. Refrigerant circuit components.
   6. Air filtration.
   7. Gas furnaces.
   8. Dampers.
   9. Electrical power connections.
   10. Controls.
   11. Roof curbs.
   12. Accessories.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of RTU.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Source quality-control reports.

F. System startup reports.

G. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Daikin
B. Trane
C. York/Johnson Controls

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." and AHRI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.02 PIPING CONNECTIONS

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

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." and Section 231126 "Facility Liquefied-Petroleum Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.03 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:
1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.04 ELECTRICAL CONNECTIONS

A. Connect electrical wiring.
B. Ground equipment.
C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Locate nameplate where easily visible.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.
B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.06 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
C. Perform tests and inspections with the assistance of a factory-authorized service representative.
D. Tests and Inspections:
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
E. RTU will be considered defective if it does not pass tests and inspections.
F. Prepare test and inspection reports.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components:
   1. Casings.
   2. Fans, drives, and motors.
   3. Coils.
   4. Refrigerant circuit components.
   5. Air filtration.
   7. Dampers.
   8. Electrical power connections.
   9. Controls.
   10. Roof curbs.
   11. Accessories.

1.02 ACTION SUBMITTALS

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

B. Product Data: For each type of RTU.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Source quality-control reports.

F. System startup reports.

G. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Daikin
B. Trane
C. York/Johnson Controls

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." and AHRI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.02 PIPING CONNECTIONS

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

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Gas Piping: Comply with applicable requirements. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

F. Refrigerant Piping: Comply with applicable requirements.

3.03 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to RTUs with flexible duct connectors.
4. Install return-air duct continuously through roof structure.

3.04 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according.

B. Ground equipment.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs.
   2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
   3. Locate nameplate where easily visible.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring.

3.06 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
SECTION 23 7433
DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.01 SUMMARY
A. Section includes factory-packaged units capable of supplying up to 100 percent outdoor air and providing cooling and heating.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.

1.03 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Roof-curb mounting details, drawn to scale, and coordinated with each other, using input from installers of the items involved:
B. Seismic Qualification Certificates: For dedicated outdoor-air units, accessories, and components, from manufacturer.
C. Startup service reports.
D. Sample warranty.

1.04 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Daikin
B. Trane
C. York/Johnson Controls
PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."
   1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
   2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
   3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."

D. Equipment Mounting:
   1. Install air units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   and Section 230548.13 "Vibration Controls for HVAC."

F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

G. Install 3000-psi, compressive-strength (28-day) concrete base inside roof curb, 4 inches thick. Concrete and reinforcement are specified with concrete.


I. Install separate devices furnished by manufacturer and not factory installed.

J. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

K. Install drain pipes from unit drain pans to sanitary drain.
   1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B88, Type L, with soldered joints.
   2. Drain Piping: Schedule 40 PVC pipe complying with ASTM D1785, with solvent-welded fittings.
   3. Pipe Size: Same size as condensate drain pan connection.

3.02 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Gas Piping Connections:
   1. Comply with requirements in Section 231123 "Facility Natural-Gas Piping." and Section 231126 "Facility Liquefied-Petroleum Gas Piping."
2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install AGA-approved flexible connectors.

C. Duct Connections:
1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

D. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.
1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.03 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
   a. Measure gas pressure at manifold.
   b. Measure combustion-air temperature at inlet to combustion chamber.
   c. Measure flue-gas temperature at furnace discharge.
   e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
   a. High-limit heat exchanger.
   b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:
   a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
   b. Cooling coil entering-air, dry- and wet-bulb temperatures.
   c. Condenser coil entering-air dry-bulb temperature.
   d. Condenser coil leaving-air dry-bulb temperature.
7. Simulate maximum cooling demand and inspect the following:
   a. Compressor refrigerant suction and hot-gas pressures.
   b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices including response to smoke
detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
   a. Supply-air volume.
   b. Return-air flow.
   c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified
   above.

D. Prepare written report of the results of startup services.

3.04 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide
   on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to
   Project during other-than-normal occupancy hours for this purpose.

END OF SECTION
SECTION 23 8126
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 SUMMARY
A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.02 ACTION SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product indicated.

1.03 INFORMATIONAL SUBMITTALS
A. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

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

B. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Mitsubishi
B. Daikin
C. York/Johnson Controls
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:
   1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations.
   2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
   3. Comply with requirements for vibration isolation and seismic control devices.
   4. Comply with requirements for vibration isolation devices.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

D. Prepare test and inspection reports.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
   A. Section includes packaged, factory-assembled and -tested, refrigerant-type, outdoor, mechanical dehumidification units designed for outdoor installation.

1.02 ACTION SUBMITTALS
   A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
   B. Product Data: For each type of outdoor, mechanical dehumidification unit.

1.03 INFORMATIONAL SUBMITTALS
   A. Seismic Qualification Data: For outdoor, mechanical dehumidification units, accessories, and components, from manufacturer.
   B. Product test reports.
   C. Field quality-control reports.
   D. Sample warranty.

1.04 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

1.05 QUALITY ASSURANCE
   A. Testing Agency Qualifications: An NRTL.

1.06 COORDINATION
   A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
   B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 OUTDOOR, MECHANICAL DEHUMIDIFICATION UNIT MANUFACTURERS
   A. Greenheck
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

3.02 INSTALLATION

A. Equipment Mounting:
   1. Install dehumidification units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations.
   2. Comply with requirements for vibration isolation and seismic control devices.
   3. Comply with requirements for vibration isolation devices.

3.03 PIPING CONNECTIONS

A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum NPS 1-1/4 copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.

D. Refrigerant Piping: Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.

E. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure, and insulate the space between roof and bottom of dehumidification unit.

3.04 ELECTRICAL CONNECTIONS

A. Connect wiring.

B. Ground equipment.

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.
   2. Locate nameplate where easily visible.
3.05 CONTROL CONNECTIONS
A. Install control and electrical power wiring to field-mounted control devices.
B. Connect control wiring between control devices.
C. Connect control wiring.
D. Connect smoke detector to fire alarm system.

3.06 FIELD QUALITY CONTROL
A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
   2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
D. Dehumidification unit will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

3.07 CLEANING
A. Clean dehumidification 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, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.08 ADJUSTING
A. Adjust damper linkages for proper damper operation.
B. Adjust initial temperature and humidity set points.

3.09 STARTUP SERVICE
A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
B. Perform the following final checks before startup:
   1. Verify that shipping, blocking, and bracing are removed.
2. 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.
3. Perform cleaning and adjusting specified in this Section.
4. 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.
5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

END OF SECTION
SECTION 26 0500
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Electrical equipment coordination and installation.
   2. Sleeves for raceways and cables.
   4. Common electrical installation requirements.

1.02 COORDINATION
A. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways and cable trays will be clear of obstructions and of the working and access space of other equipment.

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

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07.

PART 2 PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES
A. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.
   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.02 GROUT
A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION
A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch minimum annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with sealant requirements in Division 07.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with firestopping requirements in Division 07.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Exterior-Wall Penetrations: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07.

3.03 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07.

END OF SECTION
SECTION 26 0501
EQUIPMENT CONNECTIONS AND COORDINATION

PART 1 GENERAL

1.01 DESCRIPTION

A. General: Provide final connections to equipment and coordinate same in accordance with the Contract documents.

B. Equipment to receive final connections shall include but not be limited to the following:
   1. Motors and equipment.
   2. Appliances.
   3. Owner furnished equipment.

1.02 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1.03 QUALITY ASSURANCE

A. Prior to the submitting of bids, the Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment requiring electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment and the coordination thereof.

B. Connections and overcurrent protection devices shall be in accordance with the manufacturer's recommendations and approved shop drawings.

PART 2 PRODUCTS

Only those products listed in Division 26 shall be employed.

PART 3 EXECUTION

3.01 EQUIPMENT

A. Connections for and coordination of motors and equipment requiring electrical connections shall include but not be limited to the following:
   1. Provide and install a disconnect switch for each motor and each piece of equipment, except where combination starter/disconnects or disconnects integral to equipment are provided by mechanical or plumbing contractor. Provide disconnects where required by code.
   2. Verify that the motor rotation is correct and reconnect if necessary.
   3. Provide separate ground wires in flexible, metal conduit and non-metallic conduit so as to provide an electrically continuous ground path. Ground all equipment.
   4. Provide motor branch circuit conductors and connections to each individual motor controller and from each controller to the motor through an approved disconnect switch. Make final connection per Division 26 Section “Raceways and Boxes for Electrical Systems”.
   5. Where equipment is fed from branch circuit routed in or under the slab, terminate branch circuit at junction box on 2 foot rigid conduit stub-up and make final connection to equipment per Division 26 Section “Raceways and Boxes for Electrical Systems”. Provide suitable knee brace on conduit stub-up.
   6. Where equipment is fed from overhead support conduit feeder descending from ceiling on flanged floor fitting with conduit type fitting connecting to motor. Make connection per Division 26 Section “Raceways and Boxes for Electrical Systems”.
   7. Where nameplate on equipment indicates fuse protection the disconnecting means shall be equipped with dual element fuses.
3.03 APPLIANCES

A. Connections for and coordination of appliances shall include but not be limited to the following:
   1. The basic requirements for motors and equipment specified above shall apply where applicable.
   2. Where cord and plugs are provided with the appliances this contractor shall coordinate the receptacle installation to match.
   3. Direct connected equipment shall be serviced by disconnecting means.

B. Where cord and plug connections are required but not provided with the appliance this contractor shall coordinate the cord and plug and receptacle installation with General Contractor and appliance supplier.

3.05 OWNER FURNISHED EQUIPMENT

A. The requirement for equipment furnished by the Owner for installation by this contractor shall include but not be limited to the following:
   1. The coordination of the proper delivery scheduling of such equipment.
   2. The receiving and unloading of such equipment at the property line.
   3. The inspection of such equipment for damages, defacement, corrosion, missing components, etc. at the job site. All deficiencies shall be recorded. Deficiencies occurring after inspection shall be corrected by this contractor at his cost.
   4. The safe handling at secure storage of such equipment from unloading to the time of permanent installation.
   5. The completion of field make up of internal wiring as required.
   6. The lamping of equipment.
   7. The installation of accessories on such equipment.
   8. The installation of such equipment including the transportation of the equipment to the installation area, and the installation of all supports, fasteners, canopies, extensions, etc., required to insure safe support and adaptation to the finished structural, electrical and architectural conditions.
   9. The final connections and grounding to the building electrical system including all necessary labor and materials including but not limited to junction box extensions, lug change outs, etc.
   10. The testing of such equipment in its final location.

3.06 ELECTRICAL/MECHANICAL COORDINATION

A. Furnish electrical services to Division 22 and 23 equipment as outlined in Division 22 and 23 specifications.

B. Unless otherwise indicated, all mechanical equipment motors and controls shall be furnished, set in place and wired by the Division 23 contractor. The intent is to have the Division 23 contractor responsible for coordinating all control wiring, whether or not specifically called for by the mechanical or electrical drawings and specification. Comply with the applicable requirements of Division 23 for electrical work which is not otherwise specified. No extras will be allowed for Contractor’s failure to provide for these required items. The Division 26 Contractor shall refer to the Division 23 specifications and plans for all power wiring and shall advise the Architect/Engineer of any discrepancies prior to building.

C. Switches carrying full load current are to be wired under Division 26 of the work.

D. Exhaust Fans: The electrical contractor under Division 26 shall furnish and install circuits, feeders and disconnect switches, and make all connections to motors and controls unless interlocked with other mechanical equipment or lights. Where exhaust fans are switched with lights, a two-pole toggle switch will be provided under Division 26. Where exhaust fans are interlocked with other mechanical equipment, the interlock wiring will be furnished by the mechanical contractor under Division 23.

E. Electrical contractor shall provide disconnects for all starters and variable frequency drives. Electrical contractor shall provide disconnects at the equipment if it is not in line of sight of starter disconnect.

F. Electrical contractor provides control wiring to fire alarm panel and from fire alarm panel to mechanical unit.

G. All temperature control conduit and wiring shall be furnished and installed under Division 23. All motorized damper equipment shall be furnished and installed under Division 23. 120 volt power wiring shall be by Division 26.

END OF SECTION
SECTION 26 0519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

PART 2 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Wire Company.
   2. Belden Inc.
   3. Cooper Industries, Inc.
   5. General Cable; General Cable Corporation.
   7. Service Wire Co.
   8. Southwire Company.
   9. Thomas & Betts Corporation, A Member of the ABB Group.

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

C. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with NEMA WC 70/ICEA S-95-658.

E. Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.02 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   2. AFC Cable Systems, Inc.
   5. Ideal Industries, Inc.
   6. ILSCO.
   7. NSi Industries LLC.
   8. O-Z/Gedney; a brand of Emerson Industrial Automation.
   9. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Minimum conductor size shall be #12 AWG, unless specifically noted otherwise.
3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Feeders to Panelboards: Type THHN/THWN-2, single conductors in raceway.

C. Exposed Branch Circuits: Type THHN/THWN-2, single conductors in raceway.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

F. All feeders have been sized by the Engineer to limit voltage drop to 3%. The Contractor shall adjust branch circuit wiring sizes as necessary to limit voltage drop to 2%.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Install wires and cables as indicated, according to manufacturer’s written instructions and NECA’s "Standard of Installation."

C. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, which will not damage cables or raceway.

F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

G. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

D. All wiring connections made at or below grade shall be waterproof with UL listed waterproof connections.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.06 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07.
3.07 FIELD QUALITY CONTROL

A. Testing: Upon installation of wires and cables and before electrical circuitry has been energized, the Contractor shall demonstrate product capability and compliance with requirements.

B. The Contractor shall correct malfunctioning conductors and cables at Project site and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION
SECTION 26 0526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY
A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.02 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Comply with UL 467 for grounding and bonding materials and equipment.
C. Testing Agency Qualifications: Certified by NETA.

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Ground rods.
   2. Grounding arrangements and connections for separately derived systems.
C. Qualification Data: For testing agency and testing agency's field supervisor.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Burndy; Part of Hubbell Electrical Systems.
   2. ERICO International Corporation.
   3. Fushi Copperweld Inc.
   4. Galvan Industries, Inc.; Electrical Products Division, LLC.
   5. Harger Lightning & Grounding.
   6. ILSCO.
   7. O-Z/Gedney; a brand of Emerson Industrial Automation.
   8. Siemens Power Transmission & Distribution, Inc.
   9. Thomas & Betts Corporation, A Member of the ABB Group.

2.02 CONDUCTORS
A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction. Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
B. Equipment Grounding Conductors: Insulated with green-colored insulation.
C. Grounding Electrode Conductors: Stranded cable.
D. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.
E. Bare Copper Conductors:
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
   5. Bonding Conductor: No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

F. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.03 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.04 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.

3. Connections to Structural Steel: Welded connectors.

3.02 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.03 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

C. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

D. Signal and Communication Systems: For telephone, voice, data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.


2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
3.04 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building’s main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building’s grounding grid or to grounding electrode external to concrete.

3.05 FIELD QUALITY CONTROL

A. Perform tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer’s written instructions.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test well. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION
SECTION 26 0529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.02 PERFORMANCE REQUIREMENTS
A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which hangers and supports will be attached.
   3. Size and location of initial access modules for acoustical tile.
   4. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.

1.04 QUALITY ASSURANCE
A. 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 together with concrete Specifications.
B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame Rating: Class 1.
   2. Self-extinguishing according to ASTM D 635.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS
A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit; a part of Atkore International.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. Flex-Strut Inc.
e. GS Metals Corp.
f. G-Strut.
g. Haydon Corporation.
h. Metal Ties Innovation.
i. Thomas & Betts Corporation, A Member of the ABB Group.
j. Unistrut; an Atkore International company.
k. Wesanco, Inc.

4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Hilti, Inc.
      3) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      4) MKT Fastening, LLC.
   2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   5. Toggle Bolts: All-steel springhead type.

PART 3 EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Steel: Spring-tension clamps.
   5. To Light Steel: Sheet metal screws.
   6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03.

C. Anchor equipment to concrete base as follows:
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.04 PAINTING

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

B. Touchup: Comply with requirements in Division 09 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION
SECTION 26 0533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY
   A. Section Includes:
      1. Metal conduits, tubing, and fittings.
      2. Nonmetal conduits, tubing, and fittings.
      3. Metal wireways and auxiliary gutters.
      5. Handholes and boxes for exterior underground cabling.

1.02 DEFINITIONS
   A. GRC: Galvanized rigid steel conduit.
   B. IMC: Intermediate metal conduit.

1.03 SUBMITTALS
   A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
   B. Product Data: For floor boxes and handholes.

PART 2 PRODUCTS

2.01 METAL CONDUITS, TUBING, AND FITTINGS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. AFC Cable Systems, Inc.
      2. Allied Tube & Conduit; a part of Atkore International.
      3. Anamet Electrical, Inc.
      4. Electri-Flex Company.
      5. FSR Inc.
      6. O-Z/Gedney; a brand of Emerson Industrial Automation.
      7. Patriot Aluminum Products, LLC.
      8. Republic Conduit.
      9. Robroy Industries.
     10. Southwire Company.
     11. Thomas & Betts Corporation, A Member of the ABB Group.
     12. Western Tube and Conduit Corporation.
   B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   C. GRC: Comply with ANSI C80.1 and UL 6.
   D. IMC: Comply with ANSI C80.6 and UL 1242.
   E. EMT: Comply with ANSI C80.3 and UL 797.
   F. FMC: Comply with UL 1; zinc-coated steel.
   G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
   H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
      1. Fittings for EMT:
         a. Material: Steel or die cast.
         b. Type: Set-screw for conduits less than 2” and compression type for conduits 2” or larger.
      2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. Anamet Electrical, Inc.
   3. Arnco Corporation.
   4. CANTEX INC.
   5. CertainTeed Corporation.
   7. Electri-Flex Company.
   8. Kraloy.
   10. Niedax Inc.
   11. RACO; Hubbell.
   12. Thomas & Betts Corporation, A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: Comply with UL 514B.

H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.03 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-Line, Inc.; a division of Cooper Industries.
   2. Hoffman; a brand of Pentair Equipment Protection.
   3. MonoSystems, Inc.
   4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.04 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Adalet.
   2. Cooper Technologies Company.
   3. EGS/Appleton Electric.
   5. FSR Inc.
   6. Hoffman; a brand of Pentair Equipment Protection.
8. Kraloy.
10. MonoSystems, Inc.
11. Oldcastle Enclosure Solutions.
13. RACO; Hubbell.
15. Spring City Electrical Manufacturing Company.
17. Thomas & Betts Corporation, A Member of the ABB Group.
18. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:
   1. Material: Cast metal.
   2. Type: Fully adjustable.
   3. Shape: Rectangular.
   4. Legrand #EFB6S (box) with #EFB610BTXX (flush style cover with solid lid) or #EFB610CTXX (flush style cover with carpet insert). X = finish, per Architect.
   5. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

G. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.
   1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

K. Device Box Dimensions: 4 inches by 4 inches by 2-1/8 inches deep, minimum, unless noted otherwise.

L. Gangable boxes are allowed.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets:
   1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.
   6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
O. Exterior Building-Mounted Boxes: Arlington Industries InBox series with clear cover, or approved equal flush-mounted box. Provide box type and depth appropriate for exterior cladding application.

2.05  HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:
1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of fiberglass.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. NewBasis.
   d. Nordic Fiberglass, Inc.
   e. Oldcastle Precast, Inc.
   g. Synertech Moulded Products.
2. Standard: Comply with SCTE 77.
3. Color of Frame and Cover: Green.
4. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
7. Cover Legend: Molded lettering, "ELECTRIC" or "TELECOM" unless otherwise indicated.
8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 EXECUTION
3.01  RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC or IMC.
2. Concealed Conduit, Aboveground: GRC or IMC.
3. Underground Conduit: RNC, Type EPC-80-PVC.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Physical Damage: IMC. Raceway locations include the following:
   a. Mechanical rooms.
   b. Generator room.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: IMC.
6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use setscrew or compression, steel or cast-metal fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
   4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
   5. Change from ENT to GRC or IMC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:
   1. Use EMT, IMC, or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where an underground service raceway enters a building or structure.
   3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V. Expansion-Joint Fittings:
   1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
   2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
      d. Attics: 135 deg F temperature change.
   3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
   4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
   5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel. Back-to-back outlets in common walls are not permitted. Outlet boxes shall be separated by at least one stud space wherever possible. There must be a minimum of a 1" horizontal separation space between boxes of adjacent rooms. If this condition occurs in a fire rated wall, provide a 1-hour fire rated putty pad to cover the back of outlets of one side of the partition or use fire rated boxes. Other junction box installations on fire rated walls shall comply with UL requirements.
AA. Support outlet boxes and switch boxes from two (2) adjacent studs. Outlet boxes designed to attach to one metal stud and be "sandwiched" between the front and back layers of gypsum wallboard are not allowed.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Where installed in required fire rated partitions, apply fire stop putty pads on outlet boxes or install fire rated boxes as required to maintain the fire rating of the partition.

FF. Where shown adjacent to receptacles, telephone, data and cable television outlets shall be located no further than 6” on center from the center of the receptacle. Cable TV outlets and phone/data outlets shall be combined in a single faceplate.

GG. Contractor shall not install conductors or cables in a building that is not completely waterproofed, unless the conductors or cable are rated for wet location installations.

HH. Route circuit homeruns down corridors, above accessible ceilings where practicable.

II. Provide box depths and/or mud rings or extensions as necessary to accommodate wall thickness. Refer to architectural and structural drawings for wall types and thickness information.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
   1. Excavate trench bottom to provide firm and uniform support for conduit.
   2. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction.
   3. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
   4. Underground Warning Tape: Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

B. Minimum burial depth for underground conduit shall be 24”. Provide deeper burial depths where required by utility companies or local requirements.

3.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.05 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 00 "Common Work Results for Electrical."
3.06 FIRESTOPPING
A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with firestopping requirements in Division 07.

3.07 PROTECTION
A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Identification for raceways.
   2. Identification of power and control cables.
   3. Identification for conductors.
   5. Warning labels and signs.
   6. Instruction signs.
   7. Equipment identification labels, including arc-flash warning labels.
   8. Miscellaneous identification products.

B. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.02 COORDINATION
A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

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

C. Coordinate installation of identifying devices with location of access panels and doors.

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

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. Comply with NFPA 70.
C. Comply with ANSI Z535.4 for safety signs and labels.
D. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.02 LEGEND REQUIREMENTS
A. Warning labels and signs shall include, but are not limited to, the following legends:
   1. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.03 LABELS
A. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Marking Services, Inc.
      c. Panduit Corp.
      d. Seton Identification Products.
B. Self-Adhesive Labels:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A'n D Cable Products.
   b. Brady Corporation.
   c. Brother International Corporation.
   d. Emedco.
   e. Grafoplast Wire Markers.
   f. Ideal Industries, Inc.
   g. LEM Products Inc.
   h. Marking Services, Inc.
   i. Panduit Corp.
   j. Seton Identification Products.
2. Write-on, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.04 TAPES:
A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Emedco.
   d. Marking Services, Inc.
B. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
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. Carlton Industries, LP.
   b. Seton Identification Products.
C. Underground-Line Warning Tape
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. LEM Products Inc.
   d. Marking Services, Inc.
   e. Reef Industries, Inc.
   f. Seton Identification Products.
2. Tape:
   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.
   c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Color and Printing:
   a. Comply with ANSI Z535.1 through ANSI Z535.5.
   b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE."
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE", as appropriate.
4. Tag: (Label as Required):
   a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Width: 3 inches.
   c. Overall Thickness: 8 mils.
   d. Foil Core Thickness: 0.35 mil.
2.05 TAGS

A. Write-On Tags:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Carlton Industries, LP.
      b. LEM Products Inc.
      c. Seton Identification Products.
   2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
   3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.06 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:
   1. Engraved legend.
   2. Thickness:
      a. For signs up to 20 sq. inches, minimum 1/16-inch.
      b. For signs larger than 20 sq. inches, 1/8 inch thick.
      c. Engraved legend with black letters on white face.
      d. Punched or drilled for mechanical fasteners.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
   3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. Eemedco.
      d. Marking Services, Inc.

2.07 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ideal Industries, Inc.
   2. Marking Services, Inc.
   3. Panduit Corp.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.
   2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.08 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.01 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
3.02 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

F. Apply identification devices to surfaces that require finish after completing finish work.

G. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

H. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

I. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

J. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 12 to 14 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.03 IDENTIFICATION SCHEDULE

A. Accessible Raceways and AC Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive vinyl label. Install labels at origin and termination points.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:
   1. "FIRE ALARM."

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
   1. Color-Coding for Phase- and Voltage-Level] Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
      a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
      b. Colors for 208/120-V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
      c. Colors for 480/277-V Circuits:
         1) Phase A: Brown.
         2) Phase B: Orange.
3) Phase C: Yellow.
   d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer’s wiring diagrams, and operation and maintenance manual.

F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.

I. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
      d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
   2. Equipment To Be Labeled:
      a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
      b. Enclosures and electrical cabinets.
      c. Access doors and panels for concealed electrical items.
      d. Switchboards.
      e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
f. Enclosed switches.
g. Enclosed circuit breakers.
h. Variable-speed controllers.
i. Push-button stations.
j. Contactors.
k. Remote-controlled switches, dimmer modules, and control devices.
l. Disconnect Means for Equipment: Indicate the equipment being served and the panelboard and circuit numbers that are being utilized.

END OF SECTION
SECTION 26 0923
LIGHTING CONTROLS AND DEVICES
PART 1 GENERAL

1.01 SUMMARY
A. This Section includes the following lighting control devices:
   1. Occupancy and vacancy sensors.
   2. Daylight harvesting systems.

1.02 DEFINITIONS
A. LED: Light-emitting diode.
B. PIR: Passive infrared.

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Catalog sheets must clearly state any load restrictions when used with electronic ballasts.
   2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
   3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
C. Shop Drawings:
   1. Occupancy/vacancy sensors on drawings are shown to convey general intent for lighting control of spaces. Provide scaled drawings of the entire project and indicate the proper number and location(s) of occupancy/vacancy sensors, with coverage templates, to achieve desired control in each room with an occupancy sensor. Typical coverage patterns for similar room sizes (for offices, bathrooms, cabanas, etc.) will be acceptable. Upon receipt of signed release form, Engineer shall provide AutoCAD background at no charge to successful Contractor.
   2. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
   3. Interconnection diagrams showing field-installed wiring.
   4. Include diagrams for power, signal, and control wiring.
   5. Drawings will detail all control scenarios included in the project.
   6. Provide relay panel schedules showing all circuit feeds and switch legs.
   7. Provide switch schedules for all low voltage switches.
   8. Indicate a sequence of operation for all control scenarios, including manual on / auto off, auto on / auto off, sensor time delays, time schedules, control zones, and daylight harvesting set points.
D. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals. Include as-built documentation of the system.

1.04 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. All components shall be UL listed and meet all applicable state and locate code requirements.
B. Manufacturer shall substantiate conformance to this specification by supplying the necessary documents, performance data and wiring diagrams. Any deviations to this specification must be clearly stated by letter and submitted.
1.05 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.06 WARRANTY

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

B. Manufacturer’s Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.
   2. Warranty Period: Two years from date of Substantial Completion.

C. Contractor shall warrant all equipment furnished in accordance to this specification to be undamaged, free of defects in materials and workmanship, and in conformance with specifications. The supplier’s obligation shall include repair or replacement, and testing without charge to the owner all or any parts of equipment which are found to be damaged, defective or non-conforming and returned to the supplier. The warranty shall commence upon the owner’s acceptance of the project. Warranty on labor shall be for a minimum period of two years or longer if specified as such elsewhere in this specification.

PART 2 PRODUCTS

2.01 INDOOR VACANCY/OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Lighting.
   3. Douglas Lighting Control
   4. Watt Stopper (The).
   5. Cooper Controls.

B. General Description: Wall- or ceiling-mounting, solid-state indoor occupancy and vacancy sensors.
   1. Provide occupancy/vacancy sensors to control lighting as indicated on the plans. Sensors shall be installed in accordance with the 2012 IECC Sections 405.2.1.2 through C405.2.2, including but not limited to the following:
      a. Sensors shall be listed and specifically designed for the application. Sensors will be provided so as to provide full coverage of the intended area. Dual technology sensors will be provided for all offices, conference rooms and occupied work space areas. Passive infrared sensors may be used in common and storage areas, high-bay and exterior applications. Ultrasonic-only sensors may be used in corridors and restrooms. Ultrasonic-only sensors may be used in corridors and restrooms.
   4. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 A at 277-V ac for fluorescent or LED lighting, and 1/4 hp at 120-V ac.
   5. Able to be locked to either Automatic-On or Manual-On mode.
   7. Comply with NEMA WD 1, UL 20, and FS W-S-896.
   8. Relay/power packs will be plenum rated, zero-crossing 20 amp devices rated for the voltage of the lighting circuit.
   9. Operation:
      a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

10. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

11. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

12. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

13. Bypass Switch: Override the on function in case of sensor failure.

C. PIR Type: Detect occupants in coverage area by their heat and movement.
   1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
   2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
   3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 feet when mounted on a 10-foot-high ceiling.
   4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted 48 inches (1200 mm) above finished floor.

D. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
   1. Sensitivity Adjustment: Separate for each sensing technology.
   2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
   3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
      a. Provide Watt Stopper #DT-300, or approved equal by listed manufacturer.

E. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
   1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
   2. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
      a. Provide Watt Stopper #WT-1005, or approved equal by listed manufacturer.

2.02 SWITCHBOX-MOUNTED SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Lighting.
   3. Douglas Lighting Control
   4. Watt Stopper (The).
   5. Cooper Controls.

B. General Requirements for Sensors: Automatic-wall-switch occupancy or vacancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Operation: Unless otherwise indicated, manually turn lights on and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor:
1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Faceplate: Color matched to switch.

2.03 MANUAL SWITCHES AND PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.
1. Match color and style specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Wall Plates: Single and multi-gang plates as specified in Section 262726 "Wiring Devices."

C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.04 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Daylight-harvesting dimming controls are suitable for standalone, general indoor daylight-harvesting applications. Photoelectric switching controls in this article are for dimming electrical lighting as the amount of daylight reaching the coverage area increases. Daylight-harvesting dimming controls are for lighting in a single interior space. Switching range corresponds to typical interior lighting levels for the space in which lighting is mounted. Controller unit is suitable for several standard 0- to 10-V dc electronic dimming ballasts. The limit for the basis-of-design product is 50 ballasts. The power pack in this article contains circuit-switching relay(s) and powers the sensor.

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
1. Daylight zones shall be designed such that lights in the daylight zone are controlled independently of general lighting and are controlled in accordance with the 2012 IECC Section C405.2.2.31 or Section C4015.2.2.3.2, including but not limited to the following:
   a. Automatic daylight controls – Set points and other controls for calibrating the lighting control shall be “readily accessible” as defined in IECC section C405.2.2.3.2.
   b. Daylighting control devices shall be capable of automatically reducing the lighting load in response to daylight contribution.
   c. Maintain a specified foot candle level based on the contribution of natural and artificial light.
2. Lighting control set point is based on two lighting conditions:
   a. When no daylight is present (target level).
   b. When significant daylight is present.
3. System programming is done with two hand-held, remote-control tools.
   a. Initial setup tool.
b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Daylight zones under skylights shall be controlled separately of daylight zones adjacent to vertical fenestrations.

D. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with power pack, to detect changes in indoor lighting levels that are perceived by the eye.

E. Any tools or software required to adjust the system will be provided as part of the system package. This excludes foot-candle meters.

F. Electrical Components, Devices, and Accessories:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
   3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

G. Power Pack: Dry contacts rated for 20A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1HP at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
   1. LED status lights to indicate load status.
   2. Plenum rated.

H. Power Pack: Digital controller capable of accepting 3 RJ45 inputs with two outputs rated for 20A incandescent or LED load at 120- and 277-V ac, for 16A ballast load or LED at 120- and 277-V ac, and for 1HP at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
   1. With integral current monitoring
      a. Compatible with digital addressable lighting interface.
      1) Plenum rated.

2.05 DIMMING

A. The contractor shall coordinate the dimming system requirements with the lighting control system. Coordination of the devices will be the final responsibility of the contractor. No assumptions should be made in terms of the fixtures and controls indicated on the drawings. Drawings are provided to meet the design intent.

B. All dimmers will be de-rated to no more than 80% of the rated capacity.

C. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

D. Rooms with indication of preset stations shall be provided with engraved presets, to be approved by the owner, or touch screens with the ability to create and label presets. Preset creation will be limited to select users and password protected.

2.06 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors. Comply with requirements in TIA/EIA-568-C.2, Category 5e or Category 6 (to match building telecom wiring) for horizontal copper cable and in Section 271500 "Communications Horizontal Cabling."
PART 3 EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store panels according to NECA 407.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.

D. Examine walls and ceilings for suitable conditions where lighting control devices and panels will be installed.

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

3.02 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. It is the contractor's responsibility to arrange a pre-installation meeting with manufacturer's factory authorized representative, at owner's facility, to verify placement of sensors and installation criteria. Vacancy/occupancy sensors shall be located per the approved vendor submittals.

D. Proper judgment must be exercised in executing the installation so as to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components. It shall be the contractor's responsibility to locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have ninety (90) to one hundred (100) percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the respective room.

E. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

F. Set, program and adjust all devices as directed by the Owner.

G. Vacancy sensors will be programmed/installed as manual on/auto off. This shall include a low voltage switch when used in conjunction with a ceiling mounted sensor. Auto on will only be allowed under the exceptions sections of IECC section 405.2.2.2

H. Wall box sensors will be installed so that the majority of the sensor coverage is confined to the room and will provide 100% coverage of the room with minimal coverage of any adjacent corridor. Install manufacturer provided shielding to wallbox sensor switches as required to prevent false operation in locations such as office doors that remain open.

3.03 WIRING INSTALLATION

A. Comply with NECA 1.


1. Install plenum cable in environmental airspaces, including plenum ceilings.

2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

F. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

G. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 PANEL INSTALLATION
A. Comply with NECA 1.
B. Install panels and accessories according to NECA 407.
C. Mount top of trim to match height of top of panelboards.
D. Mount panel cabinet plumb and rigid without distortion of box.

3.05 IDENTIFICATION
A. Identify components and power and control wiring according to Division 26 Section “Identification for Electrical Systems.”
   1. Identify controlled circuits in lighting relay panels.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
B. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
C. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 “Identification for Electrical Systems.”

3.06 FIELD QUALITY CONTROL
A. The Contractor will set, test and verify the functionality of all lighting control components.
B. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
C. Lighting control devices that fail tests and inspections are defective work.

3.07 COMMISSIONING
A. Prior to the installation of the system, a factory authorized service technician will meet on site with the electrical foreman for the project. At this meeting the foreman will be provided a full set of approved lighting control drawings. The lighting control technician will review photocell placement, occupancy sensor requirements, switch locations, wiring requirements and any other information critical to the installation of the system.
B. Upon completion of the installation, the system shall be completely commissioned by the manufacturer's factory authorized technician who will verify all adjustments and sensor placement to ensure a trouble-free lighting control system that meets the design intent of the construction documents.
C. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the scheduled commissioning date. Upon completion of the system fine tuning the factory authorized technician shall provide the proper training to the owner's personnel in the adjustment and maintenance of the sensors.
D. Provide documentation for all daylight harvesting zones including desk top readings with lights off, lights at full and lights under daylight harvesting control. Include time, date and general weather condition (e.g. full
sun, cloudy). Include information on the testing device, foot-candle meter, etc. used. All testing and verification will be conducted by factory trained technician. Test reports will be signed by the technician.

E. The manufacturer shall provide a factory authorized technician to confirm proper installation and operation of all lighting control system components. The startup requirement is intended to verify that:
   1. All occupancy and daylighting sensors are located, installed and adjusted as intended by the factory and the contract documents.
   2. The occupancy sensors and daylighting sensors are operating within the manufacturers specifications.
   3. The sensors and relay panels interact as a complete and operational system to meet the design intent.
   4. The manufacturer shall provide a written statement verifying that the system meets the above requirements.

F. The manufacturer shall provide a factory authorized technician to train owner personnel in the operation, programming and maintenance of the lighting control system, including all occupancy sensors and daylighting controls. The contractor shall also provide, at the owner's facility, the training necessary to familiarize the owner's personnel with the adjustment, and problem solving diagnosis of the occupancy sensing devices and systems.

G. System Programming: The manufacturer shall provide system programming including:
   1. Wiring documentation.
   2. Switch operation.
   3. Operating schedules, as confirmed by the Owner.

3.08 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

B. It shall be the contractor's responsibility to make all proper adjustments to assure owner's satisfaction with the occupancy system.

3.09 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training." Training shall be videotaped and DVD shall be submitted to the Owner with the O&M Manuals.

END OF SECTION
SECTION 26 2200
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY
A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.

1.02 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. 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.
C. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals

1.03 QUALITY ASSURANCE
A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.04 DELIVERY, STORAGE, AND HANDLING
A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.05 COORDINATION
A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Concrete Section.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Match switchboard and panelboard manufacturer.

2.02 GENERAL TRANSFORMER REQUIREMENTS
A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
B. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.
C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
D. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum.

2.03 DISTRIBUTION TRANSFORMERS
A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

F. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

G. Insulation Class, 30kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

H. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.04 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Electrical Identification."

2.05 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases and anchor floor-mounting transformers according to Division 03 "Cast-in-Place Concrete", manufacturer's written instructions and requirements in Division 26.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.
3.03 CONNECTIONS
   A. Ground equipment according to Division 26 Section "Grounding and Bonding."
   B. Connect wiring according to Division 26 Section "Conductors and Cables."
   C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
   D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.04 FIELD QUALITY CONTROL
   A. Perform tests and inspections and prepare test reports.
   B. Tests and Inspections:
      1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters
   C. Remove and replace units that do not pass tests or inspections and retest as specified above.
   D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING
   A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
   B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING
   A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION
SECTION 26 2413
SWITCHBOARDS

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Surge protection devices.
   3. Disconnecting and overcurrent protective devices.
   4. Identification.

1.02 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
   1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
C. Shop Drawings: For each switchboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   5. Detail utility company's metering provisions with indication of approval by utility company.
   6. Include evidence of NRTL listing for series rating of installed devices.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
D. Provide dimensioned shop drawings of all electrical rooms showing all equipment and equipment clearance requirements. All electrical rooms have been laid out using dimensional data from specific manufacturers. Submit ¼” scale drawings of each electrical room (including satellite electrical rooms) with the actual sizes of all equipment (including fire alarm panels, lighting control panels, contactors, etc.) shown appropriately. For ease of installation, the Contractor may be permitted to rearrange the equipment in each room, provided that all NEC required clearances are maintained and wall space allotted for future equipment is maximized. All submittals must be approved prior to beginning any rough-in work.
E. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.03 QUALITY ASSURANCE
A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.04 DELIVERY, STORAGE, AND HANDLING
A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.
C. Handle and prepare switchboards for installation according to NEMA PB 2.1.
1.05 FIELD CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is
      complete and dry, work above switchboards is complete, and temporary HVAC system is operating and
      maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of
      the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

1.06 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates
   walls or is supported by them, including electrical and other types of equipment, raceways, piping,
   encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace
   clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts
   into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 PRODUCTS

2.01 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Sector; Eaton Corporation.
   2. General Electric Company.
   4. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories
   from single source from single manufacturer.

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

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   3. Sections front and rear aligned.

H. Nominal System Voltage: Refer to the Drawings.

I. Main-Bus Continuous: Refer to the Drawings.

J. Indoor Enclosures: Steel, NEMA 250, Type 1.

K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-
   inhibiting primer on treated metal surface.

L. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain
   disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding
   electrode conductor terminal, and a main bonding jumper.

M. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility
   company's requirements; hinged sealed door; buses provisioned for mounting utility company's current
   transformers and potential transformers or potential taps as required by utility company. If separate vertical
section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

N. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

O. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
   a. If bus is aluminum, use copper or tin-plated aluminum for circuit-breaker line connections.
   b. If bus is copper, use copper for feeder circuit-breaker line connections.
3. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
4. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extension.
6. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.
   b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

P. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.02 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Protection Technologies Inc. (APT).
2. Eaton Electrical Sector; Eaton Corporation.
5. Square D; by Schneider Electric.
7. Liebert.

B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
1. SPDs with the following features and accessories:
   a. Integral disconnect switch.
   b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   c. Indicator light display for protection status.
   d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
   e. Surge counter.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 240kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 700 V.
2. Line to Ground: 1200 V.
3. Line to Line: 1000 V.
2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

3. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.04 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
   1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
   2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
   3. Protect from moisture, dust, dirt, and debris during storage and installation.
   4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.02 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03.
   1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation. Set field-adjustable switches and circuit-breaker trip ranges.

G. Comply with NECA 1.

3.03 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 “Identification for Electrical Systems.”

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 “Identification for Electrical Systems.”

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems." This includes all devices in the switchboard.

D. Provide a full size drawing of the "as-built" electrical one-line diagram, laminated and mounted under 0.125" thick clear acrylic with a satin finish aluminum frame. All “as-built” comments shall be incorporated into AutoCAD and plotted for this use. Locate drawing adjacent to main switchboard.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Acceptance Testing:
   a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
   b. Test continuity of each circuit.


3. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

B. Switchboard will be considered defective if it does not pass tests and inspections.

3.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
3.07 PROTECTION
   A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.08 DEMONSTRATION
   A. Train Owner’s maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.02 DEFINITIONS
A. ATS: Acceptance testing specification.
B. GFCI: Ground-fault circuit interrupter.
C. GFEP: Ground-fault equipment protection.
D. MCCB: Molded-case circuit breaker.
E. SPD: Surge protective device.

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing. Coordinate room names and/or numbers to be used in panel schedules with final naming and numbering conventions.
D. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
E. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.

1.04 QUALITY ASSURANCE
A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.05 DELIVERY, STORAGE, AND HANDLING
A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.06 FIELD CONDITIONS
A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating
and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
   b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

PART 2 PRODUCTS

2.01 PANELBOARDS COMMON REQUIREMENTS

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

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

D. Enclosures: Flush and Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Pool equipment rooms: NEMA 4X.
   2. Height: 84 inches maximum.
   3. Hinged Front Cover (Door-in-Door type): Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   4. Finishes:
      a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

E. Phase, Neutral, and Ground Buses:
   1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
      a. Plating shall run entire length of bus.
      b. Bus shall be fully rated the entire length.
   2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
   3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

F. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
   2. Terminations shall allow use of 75 deg C rated conductors without derating.
   3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
   4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
   5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
   6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

G. NRTL Label: Where indicated, panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices.
H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
   1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
   2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.02 POWER PANELBOARDS
   A. Manufacturers: Match switchboard manufacturer.
   B. Panelboards: NEMA PB 1, distribution type.
   C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
      1. For doors more than 36 inches high, provide two latches, keyed alike.
   D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS
   A. Manufacturers: Match switchboard manufacturer.
   B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
   C. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
   D. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES
   A. MCCB: Comply with UL 489, with series-connected rating or interrupting capacity to meet available fault currents.
      1. Thermal-Magnetic Circuit Breakers:
         a. Inverse time-current element for low-level overloads.
         b. Instantaneous magnetic trip element for short circuits.
         c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
      3. MCCB Features and Accessories:
         a. Standard frame sizes, trip ratings, and number of poles.
         b. Breaker handle indicates tripped status.
         c. UL listed for reverse connection without restrictive line or load ratings.
         d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
         e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
         f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
         g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
         h. Multipole units enclosed in a single housing with a single handle.
         i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
         j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.05 IDENTIFICATION
   A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
   B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
   1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Comply with NEC A 1.
C. Install panelboards and accessories according to NEMA PB 1.1.
D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
G. Mount panelboard cabinet plumb and rigid without distortion of box.
H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
I. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer’s written instructions.
J. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
K. Install filler plates in unused spaces.
L. For flush-mounted panelboards, stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.
M. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems."
B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Panelboards will be considered defective if they do not pass tests and inspections.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
   1. Measure loads during period of normal facility operations.
   2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
   4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.06 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION
SECTION 26 2713
ELECTRICITY METERING

PART 1 GENERAL

1.01 SUMMARY
A. Section includes equipment for electricity metering by utility company and metering by Owner.

1.02 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product indicated.
C. Shop Drawings: For electricity-metering equipment.
   1. Dimensioned plans and section or elevation layouts.
   2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

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

1.04 DELIVERY, STORAGE, AND HANDLING
A. Receive, store, and handle modular meter center according to NECA 400.

1.05 COORDINATION
A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
   1. Comply with requirements of utilities providing electrical power services.
   2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 PRODUCTS

2.01 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY
A. Meters will be furnished by utility company.
B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
C. Meter Sockets: Comply with requirements of electrical-power utility company.

PART 3 EXECUTION

3.01 INSTALLATION
A. Comply with equipment installation requirements in NECA 1.
B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

3.02 IDENTIFICATION
A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
   1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.

END OF SECTION
SECTION 26 2726
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Receptacles, receptacles with integral GFCI, and associated device plates.
   2. Twist-locking receptacles.
   3. Tamper-resistant receptacles.
   5. Switches and wall-box dimmers.
   6. Cord and plug sets.
   7. Floor service outlets.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

1.04 SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label
   warnings and instruction manuals that include labeling conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
   2. Hubbell Incorporated; Wiring Device-Kellems.
   3. General Electric (GE)
   4. Leviton Manufacturing Co., Inc.
   5. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from
   single manufacturer.

2.02 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

2.03 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6
   Configuration 5-20R, and UL 498.
2.04 **GFCI RECEPTACLES**

A. **General Description:**
   1. Straight blade, non-feed-through type.
   2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
   3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
   4. Square face, 125 V, 20 A.

2.05 **TWIST-LOCKING RECEPTACLES**

A. **Single Convenience Receptacles, 125 V, 20 A:** Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, match receptacle manufacturers listed above.

2.06 **PENDANT CORD-CONNECTOR DEVICES**

A. **Description:**
   1. Matching, locking-type plug and receptacle body connector.
   2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
   4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.07 **CORD AND PLUG SETS**

A. **Description:**
   1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.08 **TOGGLE SWITCHES**

A. **Comply with NEMA WD 1, UL 20, and FS W-S-896.**

B. **Switches, 120/277 V, 20 A:**
   1. **Square face, specification grade, quiet-type, Single Pole, Two Pole, 3-Way and 4-Way:**
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Eaton (Arrow Hart).
         2) General Electric (GE).
         3) Hubbell Incorporated; Wiring Device-Kellems.
         4) Leviton Manufacturing Co., Inc.
         5) Pass & Seymour/Legrand (Pass & Seymour).
   C. **Single-Pole Timer Switches:** 1000W, 120V AC, 60Hz, Single-Pole, Decora-style, four presets in 2-5-10-15 minute increments. Leviton, no equals allowed.

2.09 **WALL PLATES**

A. **Single and combination types shall match corresponding wiring devices.**
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material: 0.035-inch thick, satin-finished stainless steel.
   4. Material for Damp Locations: 0.035-inch thick, satin-finished stainless steel.

B. **Wet-Location, Weatherproof Cover Plates:** NEMA 250, complying with type 3R weather-resistant. Cover shall comply with NEC and maintain wet-location listing while device(s) is(are) plugged in. Coverplate shall be compatible with exterior receptacle box. Refer to Section 260533.
2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
   1. Compartments: Barrier separates power from voice and data communication cabling.
   2. Service Plate: Rectangular, solid brass with satin finish.
   3. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
      Comply with requirements in Section 271500 "Communications Horizontal Cabling."

2.11 FINISHES

A. Device Color:
   1. Wiring Devices: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:
   1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:
   2. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
   3. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   4. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   5. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   6. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
   7. Use a torque screwdriver when a torque is recommended or required by manufacturer.
   8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   9. Tighten unused terminal screws on the device.
   10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
   2. Half-switched receptacles shall have the ground pin at the top and the lower outlet shall be switched.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Group adjacent switches under single, multigang wall plates.
H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.
I. Locate above-counter receptacles to comply with ADA accessibility requirements.

3.02 IDENTIFICATION
A. Comply with Section 26 05 53 "Identification for Electrical Systems."
B. Identify each receptacle with panelboard identification and circuit number. Use permanent marker on back of faceplate and durable wire markers or tags inside outlet boxes.

3.03 FIELD QUALITY CONTROL
A. Perform the following tests and inspections:
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
C. Wiring device will be considered defective if it does not pass tests and inspections.
D. Replace damaged or defective components.

END OF SECTION
SECTION 26 2813
FUSES

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in enclosed switches.
   2. Spare fuse cabinet.

1.02 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.
   3. Coordination charts and tables and related data.
C. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Furnish one set of three of fuse size and type.

1.03 FIELD CONDITIONS
A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann; a division of Cooper Industries.
   2. Edison; a brand of Cooper Bussmann; a division of Cooper Industries.
   3. Littelfuse, Inc.
   4. Mersen USA.
B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.02 CARTRIDGE FUSES
A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
C. Comply with NEMA FU 1 for cartridge fuses.
D. Comply with NFPA 70.
E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.03 SPARE-FUSE CABINET
A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Motor Branch Circuits: Class RK1, time delay, unless otherwise recommend by equipment manufacturer.
   2. Other Branch Circuits: Class RK5, time delay.
   3. Control Circuits: Class CC, fast acting.

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
B. Install spare fuse cabinet in main electrical room.

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION
SECTION 26 2816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Molded-case circuit breakers (MCCBs).
   4. Enclosures.

1.02 DEFINITIONS

A. NO/NC: Normally Open / Normally Closed.

1.03 SUBMITTALS

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

B. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
   1. Manufacturer’s written instructions for testing and adjusting enclosed switches and circuit breakers.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

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

C. Comply with NFPA 70.

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet.

1.06 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 PRODUCTS

2.01 FUSIBLE SWITCHES

A. Manufacturer: Match switchboard and panelboard manufacturer.
B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Where indicated, two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.02 NONFUSIBLE SWITCHES

A. Manufacturer: Match switchboard and panelboard manufacturer.

B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Where indicated, two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.03 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturer: Match switchboard and panelboard manufacturer.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated or series rated as indicated on the Drawings or required by other sections of these Specifications. Circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 75 deg C rated wire, sized according to the 75 deg C temperature rating in NFPA 70.

G. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.


J. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
   4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   5. Auxiliary Contacts: Where indicated, Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.04 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R.
   3. Pool and other corrosive atmospheres: NEMA 250, Type 4X.

B. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts.

C. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

D. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

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

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.03 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.04 FIELD QUALITY CONTROL

A. Testing: After installing disconnect switches and circuit breakers and after electrical circuitry has been energized, the Contractor shall demonstrate product capability and compliance with requirements.

B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION
SECTION 26 5100
INTERIOR LIGHTING

PART 1 GENERAL

1.01 SUMMARY
A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, lamps, emergency lighting units, and accessories.

1.02 DEFINITIONS
A. CCT: Correlated Color Temperature.
B. CRI: Color Rendering Index.
C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
D. Fixture: See “Luminaire.”
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector and housing.

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
   1. Physical description and dimensions of luminaires.
   2. Include battery and charger data for emergency lighting units.
   3. Lamp(s).
   4. Include life, output (lumens, CCT and CRI), and energy efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM45, IES LM-79, and IES LM-80.
      a. Manufacturers’ Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.
D. Dimming Driver Compatibility Certificates: Signed by manufacturer of driver certifying that drivers are compatible with dimming systems and equipment with which they are used.
E. Operation and Maintenance Data: For luminaires and lighting systems to include in maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers’ codes.

1.04 QUALITY ASSURANCE
A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer’s laboratory is accredited under the NVLAP for Energy Efficient Lighting Products.

1.05 DELIVERY, STORAGE AND HANDLING
A. Protect finished of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.06 WARRANTY
A. See Section 01 7800 – Closeout Submittals, for additional requirements.
B. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Two years from date of Substantial Completion.
2. Warranty Period for LED Luminaires: Five years from date of Substantial Completion.

C. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

1.07 COORDINATION
A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings.

2.02 LUMINAIRE REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. NRTL Compliance: Fabricated and label emergency lighting units, exit signs and batteries to comply with UL 924.
C. Lamp base complying with ANSI C81.61.
D. Nominal Operating Voltage: 120 V ac.
E. Recessed Luminaires: Comply with NEMA LE 4.
F. Comply with NFPA 70 and NFPA 101 for emergency lighting.
G. Bulb Shape: Complying with ANSI C79.1 for incandescent, LED, and emergency lighting.

2.03 LED
A. CRI of 80, minimum. CCT of as indicated on the Light Fixture Schedule.
B. Rated lamp life of minimum 50,000 hours.
C. Lamps dimmable from 100 percent to 0 percent of maximum light output.
D. Internal driver.
E. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
F. Minimum allowable luminaire efficacy of 80 lumens per watt.

2.04 EXIT SIGNS
A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
B. Internally Lighted Signs:
1. Operating at nominal voltage of 120 V ac.
2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
3. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.05 EMERGENCY LIGHTING POWER UNITS
A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with lamps. Comply with UL 924.
1. Test Push Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2. Battery: Sealed, maintenance-free, nickel-cadmium type.
3. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
4. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.06 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
   1. Glass: Annealed crystal glass unless otherwise indicated.
   2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:
   1. Extruded-aluminum housing and heat sink.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. “USE ONLY” and include specific lamp type.
      b. Lamp diameter, shape, size, wattage, and coating.
      c. CCT and CRI for all luminaires.

2.07 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.08 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.


D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod

E. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation.

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

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them.

E. Supports:
1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

F. Ceiling-Grid-Mounted Luminaire Supports: Use grid as a support element.
1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches from luminaire corners.
2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.

G. Flush-Mounted Luminaire Support:
1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

H. Wall-Mounted Luminaire Support:
1. Attached to structural members in walls or attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

I. Suspended Luminaire Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.04 CONNECTIONS

A. Ground equipment.
1. 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.
3.05 IDENTIFICATION
   A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification
      specified in Section 260553 “Identification for Electrical Systems.”

3.06 FIELD QUALITY CONTROL
   A. The Contractor shall inspect each installed fixture for damage. Replace damaged fixtures and
      components.
   B. Tests: As follows:
      1. Verify normal operation of each fixture after installation.
      2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
   C. Malfunctioning Fixtures and Components: The Contractor shall replace or repair, then retest. Repeat
      procedure until units operate properly.
   D. Corrosive Fixtures: Replace during warranty period.

3.07 START-UP SERVICE
   A. Perform startup service:
      1. Charge emergency power units minimum of one hour and depress switch to conduct short-duration
         test.

3.08 CLEANING AND ADJUSTING
   A. Clean fixtures internally and externally after installation. Use methods and materials recommended by
      manufacturer. All luminaires shall be thoroughly cleaned and clear from dust, paint, construction debris
      and fingerprints after all other trades are complete, but prior to the date of substantial completion.
   B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-
      site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to one
      visits to Project during other-than-normal hours for this purpose. Some of this work may be required during
      hours of darkness.
      1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
      2. Parts and supplies shall be manufacturer’s authorized replacement parts and supplies.
      3. Adjust the aim of luminaires in the presence of the Architect.
   C. Emergency Lighting Adjustments:
      1. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the
         following:
         a. Inspect all luminaires. Replace lamps, emergency power units signs, or luminaires that are
            defective.
            1) Parts and supplies shall be manufacturer’s authorized replacement parts and supplies.
         b. Conduct short-duration tests on all emergency lighting.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Exterior sold-state luminaires that are designed for and exclusively use LED lamp technology.

1.02 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color-rendering index.
C. Fixture: See "Luminaire."
D. Lumen: Measured output of lamp and luminaire, or both.
E. Luminaire: Complete lighting fixture, including ballast housing if provided.
F. Pole: Luminaire support structure.
G. Standard: Same definition as "Pole" above.

1.03 SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of luminaire.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Ballast, including BF.
   5. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   6. Manufacturer's Certified Data: Photometric data certified by manufacturer’s laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
   7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.
D. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers’ laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
B. Provide luminaires for a single manufacturer for each luminaire type.
C. Each LED luminaire type shall be binned within a three-step MacAdam Ellipse minimum to ensure color consistency among luminaires.
D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
F. Comply with NFPA 70.
1.05 DELIVERY, STORAGE, AND HANDLING
   A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.06 FIELD CONDITIONS
   A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
   B. Mark locations of exterior luminaires for approval by Architect and/or Landscape Architect prior to the start of luminaire installation.

1.07 WARRANTY
   A. See Section 01 7800 – Closeout Submittals, for additional warranty requirements.
   B. Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
      1. Failures include, but are not limited to, the following:
         a. Structural failures, including luminaire support components.
         b. Faulty operation of luminaires, ballasts, and accessories.
         c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
      2. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 PRODUCTS
2.01 LUMINAIRE REQUIREMENTS
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. Nominal Operating Voltage: 120 V ac.
   C. In-line Fusing: Separate in-line fuse for each luminaire.
   D. Source Limitations: Obtain luminaires from single source from a single manufacturer.
   E. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.
   F. Lateral Light Distribution Patterns: Comply with IES RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
   G. LED: Bulb shape complying with ANSI C79.1 L70 lamp life of minimum 50,000 hours. Internal driver.

2.02 MANUFACTURERS
   A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings.

2.03 MATERIALS
   A. Metal Parts: Free of burrs and sharp corners and edges.
   B. Sheet Metal Components: Form and support to prevent warping and sagging.
   C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Ballast shall automatically disconnect when door opens.
   D. Diffusers and Globes:
      1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      2. Glass: Annealed crystal glass unless otherwise indicated.
      3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.
E. Lens and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

G. Housings:
   1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
   2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. “USE ONLY,” including specific lamp type.
      b. Lamp diameter, shape, size, wattage, and coating.
      c. CCT and CRI for all luminaires.

2.04 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.

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

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Support luminaires without causing deflection of finished surface.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls or attached to a minimum 1/8-inch backing plate attached to
      wall structural members.


H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires
   at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and
   260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.04 BOLLARD LUMINAIRE INSTALLATION
   A. Align units for optimum directional alignment of light distribution.

   B. Install on concrete base. Cast conduit into base, and shape base to match shape of bollard base. Finish by
      troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03
      Section "Cast-in-Place Concrete."

3.05 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES
   A. Install on concrete base. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete
      materials, installation, and finishing are specified in Division 03 Section “Cast-in-Place Concrete.”

3.06 CORROSION PREVENTION
   A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal,
      protect aluminum by insulating fittings or treatment.

   B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems.” In concrete
      foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent
      overlap.

3.07 IDENTIFICATION
   A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification
      specified in Section 260553 "Identification for Electrical Systems."

3.08 FIELD QUALITY CONTROL
   A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

   B. Perform the following tests and inspections with the assistance of a factory-authorized service
      representative:
      1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry
         has been energized, test units to confirm proper operation.

   C. Illumination Tests:
      1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry
         has been energized, test units to confirm proper operation

   D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting
      results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

   E. Luminaire will be considered defective if it does not pass tests and inspections.

3.09 ADJUSTING
   A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-
      site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to one
      visit to Project during other-than-normal hours for this purpose. Some of this work may be required during
      hours of darkness.
      1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION
SECTION 26 5613
LIGHTING POLES AND STANDARDS

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. Poles and accessories for support of luminaires.

1.02 DEFINITIONS
A. EPA: Equivalent projected area.
B. Luminaire: Complete lighting fixture.
C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.
D. Standard: See "Pole."

1.03 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.
   1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
   2. Include finishes for lighting poles and luminaire-supporting devices.
   3. Anchor bolts.
   4. Manufactured pole foundations.
C. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.

1.04 DELIVERY, STORAGE, AND HANDLING
A. Package aluminum poles for shipping according to ASTM B 660.
B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
C. Retain factory-applied pole wrappings on poles until right before pole installation. Handle poles with web fabric straps.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.02 STEEL POLES
A. Manufacturers: Subject to compliance with requirements, provide products by exterior lighting manufacturer.
B. Source Limitations: Obtain poles from single manufacturer or producer.
C. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.
   1. Shape: See light fixture schedule.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
D. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
   1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

E. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

F. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

G. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
   3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.
      a. Color: As indicated by manufacturer's designations.

2.03 POLE ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 262726 "Wiring Devices."
   1. Surface mounted 12 inches above finished grade.
      a. NEMA 250, Type 3R, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
      b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

2.04 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi.
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
   2. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.

C. Washers: ASTM F 436, Type 1.
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.

2.05 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.02 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor Bolts: Install plumb using manufacturer-supplied template, uniformly spaced.

3.03 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.
   1. Fire Hydrants and Water Piping: 60 inches.
   3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
   1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers unless otherwise indicated.
   4. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.04 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50-percent overlap.
3.05 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundation.

3.06 IDENTIFICATION

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

END OF SECTION
SECTION 27 1100

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.01 SUMMARY

A. Sections Includes:
   1. Telecommunications mounting elements.
   2. Backboards.
   3. Telecommunications equipment racks and cabinets.
   4. Telecommunication service entrance pathways.
   5. Grounding.

1.02 DEFINITIONS


B. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

C. LAN: Local area network.

1.03 SUBMITTALS

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

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finished for equipment racks and cabinets.
   2. Include rated capacities, operating characteristics, electrical characteristics and furnished specialties and accessories.

C. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and locations and size of each field connection.
   2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
   3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
   4. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
      a. Vertical and horizontal offsets and transitions.
      b. Clearances for access above and to side of cable trays.
      c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
      d. Load calculations to show dead and live loads as not exceeding manufacturer’s rating for tray and its support elements.

D. Qualification Data: For Installer, layout technician, installation supervisor, and field inspector.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Prepare of Show Drawings shall be under the direct supervision of RCDD.
   2. Installation Supervisor: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   3. Field Inspector. Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and applications.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-B.
D. Grounding: Comply with TIA-607-B, NEC, and AHJ requirements.

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather-tight wet work in spaces is complete and dry, and work above ceilings is complete.

1.06 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner’s telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
1. Meet jointly with telecommunications and LAN equipment supplier, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangements and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connections. And patch panels of cabling systems of other communications, electronic safety and security and relates systems that share space in equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA-569-B.

B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening reusable straps to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

C. Cable Trays:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CPI
   b. Cablofil Inc.
   c. Cooper B-Line, Inc.
2. Cable Tray Materials: Metal, suitable for indoor and protected against corrosion by hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than .002165 thick.
   a. Ladder Cable Trays: See drawings for specification.

D. Conduit and Boxes – Comply with requirements in Division 26 Section “Raceway and Boxes for Electrical Systems.”

2.02 BACKBOARDS.

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels specified in Section 06 10 00 “Rough Carpentry.”

2.03 EQUIPMENT FRAMES

A. Manufacturers: Provide equipment shown on drawings or an approved equal by one of the following:
1. Hubbell
2. Chatsworth
3. Dell

B. General Frame Requirements:
1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
3. Finish: Manufacturer's standard, baked-polyester powder coat.

C. Floor-Mounted Racks: Modular-type, steel or aluminum construction.
   1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
   2. Baked-polyester powder coat finish.

D. Modular Freestanding Cabinets:
   1. Removable and lockable side panels.
   2. Hinged and lockable front and rear doors.
   3. Adjustable feet for leveling.
   4. Screened ventilation openings in the roof and rear door.
   5. Cable access provisions in the roof and base.
  10. All cabinets keyed alike.

E. Cable Management for Equipment Frames:
   1. Metal, with integral wire retaining fingers.
   2. Baked-polyester powder coat finish.
   3. Vertical cable management panels shall have front and rear channels, with covers.
   4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.04 POWER STRIPS

A. Power Strips: Comply with UL 1363.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Rack mounting.
   4. LED indicator lights for power and protection status.
   5. LED indicator lights for reverse polarity and open outlet ground.
   6. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
   7. Close-coupled, direct plug-in.
   8. Rocker-type on-off switch, illuminated when in on position.
  10. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than 330V.

2.05 GROUNDING

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors and the drawings.

B. Telecommunications Main Grounding Bus-bar.
   1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connections to ground bus bar.
   2. Ground Bus Bar. Copper minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
   3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Telecommunications Grounding Bus-bar.
   1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long barrel, two-bold connection to ground bus bar.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

D. Comply with TIA, NEC, and AHJ requirements.

2.06 LABELING
A. Comply with TIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 EXECUTION

3.01 ENTRANCE FACILITIES
A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

3.02 INSTALLATION
A. Comply with NECA 1.
B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
D. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
   1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
   2. Record agreements reached in meetings and distribute them to other participants.
   3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
   4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
F. Ladder Rack installation requirements.
   1. Provide all components of the ladder rack system (ladder rack, turns, splices, supports, and accessories) from a single manufacturer.
   2. Ladder rack shall be secured to the structural ceiling, building truss system, wall, floor or the tops of equipment racks and/or cabinets using the manufacturer's recommended supports and appropriate hardware as defined by local code or the authority having jurisdiction (AHJ).
   3. Ladder rack shall be supported every 5' or less in accordance with TIA-569-B. Ladder rack shall be supported within 2' on both/all sides of every splice or intersection. Support ladder rack on both sides of every change in elevation.
   4. Secure ladder rack to each support with included hardware so that at minimum ladder rack is connected to each support by two fasteners.
   5. Ladder rack splices will be made in mid-span, not over a support, with the manufacturer's recommended splice hardware.
   6. Heavy-duty splices are recommended for ladder rack in excess of 18" width. Heavy-duty splices are required for any splice formed in the vertical orientation including changes in elevation formed using vertical-to-horizontal 90° turns or horizontal-to-vertical 90° turns. Use heavy-duty splices to secure all overhead turns to the overhead horizontal pathway(s).
7. When the pathway is overhead, ladder rack shall be installed with a minimum clearance of 12” above the ladder rack. Leave a minimum of 12” in between ladder rack and ceiling/building truss structure. Leave a minimum of 3” in between ladder rack and the tops of equipment racks and/or cabinets. Multiple tiers of ladder rack shall be installed with a minimum clearance of 12” in between the ladder rack. When located above an acoustical drop ceiling, ladder rack shall be installed a minimum of 3” above the drop ceiling tiles.

8. When installed under a raised floor, ladder rack shall be installed with a minimum 3” clearance between the top of the ladder rack and the bottom of the floor tiles or floor system stringers, whichever is lower in elevation. Maintain a 3” clearance between ladder racks wherever ladder racks cross.

9. Within each telecommunications room, ladder rack should be bonded together, electrically continuous, and bonded to the TGB, unless otherwise noted in the specifications and contract documents. Ladder rack and turns shall be bonded across each splice with a UL Classified Splice Kit or other accepted method as recommended by the AHJ. Ladder rack shall be bonded to the Telecommunications Grounding Busbar (TGB) using an approved ground lug on the ladder rack and a minimum #6 grounding wire or as recommended by the AHJ. Verify the bonds at splices and intersections between individual ladder rack sections and turns and the bond to the TGB.

10. The quantity of cables within the ladder rack will not exceed a whole number value equal to 50% of the interior area of the ladder rack divided by the cross-sectional area of the cable. The interior area of ladder rack will be considered to be the width of the ladder rack multiplied by a height of 2”, unless cable retaining posts are added to the ladder rack. The interior area of ladder rack equipped with cable retaining posts will be considered to be the width of the ladder rack multiplied by a height of 6”. Actual cable fill for ladder rack that is not equipped with cable retaining posts will not exceed 2” in height. Actual cable fill for ladder rack equipped with cable retaining posts will not exceed 6” in height.

11. The combined weight of cables within the ladder rack will not exceed the stated load capacity of the ladder rack as stated in the manufacturer’s product specifications or design tables.

12. Cables (cable bundles) will be secured to the cross members of ladder rack with ¾” wide reusable straps. Straps are not required when ladder rack is equipped with cable retaining posts.

13. Separate different cable media types within the ladder rack pathway. Treat each type of cable media separately when determining cable fill limits.

14. Where cable exits or enters the side of overhead ladder rack to access a rack, frame, cabinet or wall-mounted rack, cabinet or termination field, a radius drop will be used to guide the cable.

15. Maintain a minimum separation of 2’ between ladder rack used for communications cables and pathways for other utilities or building services.

3.03 FIRE-STOPPING

A. Comply with requirements in Division 07 Section "Penetration Fire-stopping."
C. Comply with BICSI TDMM, "Fire-stopping Systems" Article.

3.04 GROUNDING

A. Comply with NEC and AHJ requirements.
B. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG copper grounding electrode conductor from grounding bus bar to suitable electrical building ground.
C. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG copper equipment grounding conductor.
D. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.05 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Labels shall be preprinted or computer-printed type.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY
   A. Section Includes:
      1. Pathways.
      2. UTP cable.
      3. 50/125-micrometer, OM4, Multimode, all dielectric, armored, optical fiber cabling.
      5. Cable connecting hardware, patch panels, and cross-connects.

1.02 DEFINITIONS
   B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
   C. EMI: Electromagnetic interference.
   D. IDC: Insulation displacement connector.
   E. LAN: Local area network.
   F. RCDD: Registered Communications Distribution Designer.
   G. UTP: Unshielded twisted pair.

1.03 BACKBONE CABLING DESCRIPTION
   A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection. All backbone and horizontal cabling including associated hardware shall be by the same Manufacturer.
   B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.04 PERFORMANCE REQUIREMENTS
   A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

1.05 SUBMITTALS
   1. See Section 01 3000 – Administrative Requirements, for submittal procedures.
   2. Product Data: For each type of product indicated.
   3. Shop Drawings:
      a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
      b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
      c. Cabling administration drawings and printouts.
      d. Wiring diagrams to show typical wiring schematics including the following:
         1) Cross-connects.
         2) Patch panels.
         3) Patch cords.
      e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
1.06 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

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

D. Telecommunications Pathways and Spaces: Comply with TIA-569-B.

E. Grounding: Comply with NEC and the AHJ requirements.

1.07 DELIVERY, STORAGE AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
   2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

1.08 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.09 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA-569-B.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with Velcro slots for securing cable with Velcro.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

C. Conduit and Boxes: Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
   1. Outlet boxes shall be no smaller than 4 inches wide, 4 inches high, and 2-1/2 inches deep.

2.02 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following O.A.E:
   1. Belden CDT Inc.; Electronics Division.
   2. Berk-Tek; a Nexans Company.
   3. CommScope, Inc.
   4. Superior Essex, Inc.
5. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, Multi-pair UTP, formed into 25-pair binder groups covered with a thermoplastic jacket.
   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with TIA-568-C.1 for performance specifications.
   3. Comply with TIA-568-C.2, Category 3.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
      b. Communications, Riser Rated: Type CMR, comply with UL 1666.

2.03 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements and operate as a warrantied system with cabling, provide products by one of the following O.A.E:
   1. Hubbell Premise Wiring.
   2. Leviton Voice & Data Division.
   3. Siemon Co. (The).
   4. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
   1. Number of Terminals per Field: Four for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   1. See drawings for quantity.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

G. Patch Cords: Factory-made, 4-pair cables in lengths suitable for proper patching with 12” of slack in each cord; terminated with 8-position modular plug at each end.
   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
   2. Patch cords shall have color-coded boots for circuit identification.
   3. Provide quantity of 1.10 X number of terminated/tested cables.
   4. Confirm color with the Owner.

2.04 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, O.A.E.:
   1. Mohawk
   2. Belden
   3. Berk-Tek; a Nexans company.
   4. CommScope, Inc.
   5. Corning Cable Systems.
   6. Superior Essex Inc.
   7. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Multimode, 50/125 micrometer, OM4, Loose-tube, Interlocking-Armored, Indoor/Outdoor, Optical-fiber cable.
   2. Comply with TIA568-C.3 for optical fiber component standards.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL
444, UL 1651, and NFPA 70 for the following types:
   a. National Electrical Code® (NEC®) OFCP, CSA FT-6
   b. Outdoor aerial and duct; indoor vertical riser and general purpose horizontal according to NEC
      Article 770.
   c. ANSI/ICEA S-104-696; NFPA 262 (for plenum, riser and general building applications).
4. Maximum attenuation: 2.8 dB/km / 1.0 dB/km.

C. Jacket:
   1. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
   2. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40
      inches.

2.05 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements and operate as a warranted system with cabling,
   provide products by one of the following, O.A.E.:
   1. Hubbell
   2. Corning
   3. Superior Essex Inc.
   4. Commscope
   5. Tyco/AMP Netconnect

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
   1. Number of Connectors per Field: One for each pair of fiber cables assigned to field, plus spares and
      blank positions adequate to suit a minimum of 25% expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in custom lengths to provide a maximum of 24” of slack post
   termination.

D. Cable Connecting Hardware:
   1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2,
   2. Quick-connect, duplex, Type LC connectors. Insertion loss not more than 0.75 dB
   3. Type SFF connectors may be used in termination racks, panels, and equipment packages.
   4. Fusion-spliced pigtauls only. No crimp connectors.

2.06 COAXIAL CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following O.A.E.:
   1. Belden CDT Inc.; Electronics Division.
   2. CommScope, Inc.
   3. Superior Essex

B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically
   for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal
   impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG-11/U: NFPA 70, Type CATV.
   1. No. 14 AWG, solid, copper-covered steel conductor.
   2. Gas-injected, foam-PE insulation.
   3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
   4. Jacketed with sunlight-resistant, black PVC or PE.
   5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg. C.

D. RG-6/U: NFPA 70, Type CATV or CM.
   1. Quad Shield
   2. Jacketed with black PVC or PE.
   3. Suitable for indoor installations.

E. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as
   complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna
   Television and Radio Distribution" Articles. Types are as follows:
1. CATV Cable: Type CATV.
2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
3. CATV Riser Rated: Type CATVR, complying with UL 1666.
4. CATV Limited Rating: Type CATVX.

2.07 COAXIAL CABLE HARDWARE
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, O.A.E.:
   1. Belden
   2. Leviton Voice & Data Division.
   3. Siemon Co. (The).
B. Coaxial-Cable Connectors: Type F, 75 ohms.

2.08 GROUNDING
A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
B. Comply with TIA-607-B.
C. Comply with drawings.

2.09 IDENTIFICATION PRODUCTS
A. Comply with TIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.10 SOURCE QUALITY CONTROL
A. Testing: All cable testing shall be performed by a BICSI certified technician and reviewed and stamped by an RCDD.
B. Factory test cables on reels according to TIA -568-C.1.
C. Factory test UTP cables according to TIA -568-C.2.
D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA-568-C.3.
E. Cable will be considered defective if it does not pass tests and inspections.
F. Prepare test and inspection reports.

PART 3 EXECUTION
3.01 ENTRANCE FACILITIES
A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS
A. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors.
B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Use a minimum of ¾” wide Velcro, no plastic “zip-ties”.

3.03 INSTALLATION OF PATHWAYS
A. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
B. Comply with TIA/EIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
C. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

D. Install manufactured conduit sweeps and long-radius elbows whenever possible.

E. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits 3 inches above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.04 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
   7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
   8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
   10. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
   11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
   2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical fiber Cable Installation:
   2. Cable may be terminated on connecting hardware that is rack mounted.

E. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend UTP cable not in a wire-way or pathway, a minimum of 8 inches above ceilings by cable supports not more than 48 inches apart.
   3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Outdoor Coaxial Cable Installation:
   1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:
   1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.05 FIRESTOPPING

   A. Comply with requirements in Division 07 Section “Penetration Firestopping.”

3.06 GROUNDING

   A. Install grounding according to BICSI TDMM, Grounding, Bonding, and Electrical Protection” Chapter.
   B. Comply with TIA-607-B, NEC, and the AHJ requirements.
   C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
   D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.07 IDENTIFICATION

   A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 “Identification for Electrical Systems.”
      1. Administration Class: 2.
      2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
   B. Comply with requirements in Division 09 Section “Interior Painting” for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
   C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration including optional identification requirements of this standard.
D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:
1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
   a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
   b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-B, for the following:
1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.08 FIELD QUALITY CONTROL

A. Contractor shall perform tests and inspections.

B. Tests and Inspections:
1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
4. Optical Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA-568-C.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports that have been reviewed and stamped by an RCDD.

END OF SECTION
SECTION 27 1500
COMMUNICATIONS HORIZONTAL CABLING

PART 1 GENERAL

1.01 SUMMARY
A. Section Includes:
   1. UTP cabling.
   2. Coaxial cable.
   3. Cable connecting hardware, patch panels, and cross-connects.
   4. Telecommunications outlet/connectors.
   5. Cabling system identification products.
   6. Cable management system.

1.02 DEFINITIONS
B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
C. EMI: Electromagnetic interference.
D. IDC: Insulation displacement connector.
E. LAN: Local area network.
F. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
G. RCDD: Registered Communications Distribution Designer.
H. UTP: Unshielded twisted pair.

1.03 HORIZONTAL CABLING DESCRIPTION
A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a “permanent link,” a term that is used in the testing protocols.
   1. TIA-568-C.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
   2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
   3. Bridged taps and splices shall not be installed in the horizontal cabling.
   4. Splitters shall not be installed as part of the optical fiber cabling.
B. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment and in the horizontal cross-connect.

1.04 PERFORMANCE REQUIREMENTS
A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1 when tested according to test procedures of this standard.

1.05 SUBMITTALS
A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
C. Shop Drawings:
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:
   b. Patch panels.
   c. Patch cords.
5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test each pair of UTP cable for open and short circuits.

1.08 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver of install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.09 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with the Owner’s telecommunications and LAN equipment and service suppliers. Arrange for a pre-installation meeting with the Owner prior to beginning any rough-in, or installing any cables.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

PART 2 PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA-569-B.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with slots for reusable straps. Use reusable straps, not cable ties.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

2.02 UTP CABLE

A. Manufacturers: All cable, hardware, and patch cords shall be by the same Manufacturer. Subject to compliance with requirements, provide products by one of the following O.A.E.:
   1. Belden.
   2. Berk-Tek; a Nexans company.
   3. CommScope, Inc.
   4. Superior Essex Inc.
5. Tyco Electronics Corporation; AMP Products.

B. Description: 100-ohm, four-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with TIA/EIA-568-B.1 for performance specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
      b. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

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

E. Grounding: Comply with NEC and the AHJ requirements.

2.03 UTP CABLE HARDWARE

A. Manufacturers: All cable, hardware, and patch cords shall be by the same Manufacturer. Subject to compliance with requirements, provide products by one of the following O.A.E.:
   1. Belden
   2. Hubbell Premise Wiring.
   3. Leviton Commercial Networks Division.
   4. Ortronics.
   5. Panduit Corp.
   7. Tyco Electronics Corporation; AMP Products.

B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   1. See drawings for quantities.

E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

F. Patch Cords: Factory-made, 4-pair cables in lengths, by the same manufacturer as the horizontal cable, suitable for proper patching with 12” of slack in each cord plus or minus 3 inches; terminated with 8-position modular plug at each end.
   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
   2. Patch cords shall have color-coded boots for circuit identification.
   3. Provide quantity of 0.80 X number of terminated/tested cables.
   4. Confirm color with the Owner.

2.04 COAXIAL CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following O.A.E.:
   1. Belden CDT Inc.; Electronics Division.
   2. CommScope, Inc.
   3. Superior Essex
B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG-11/U: NFPA 70, Type CATV.
   1. No. 14 AWG, solid, copper-covered steel conductor.
   2. Gas-injected, foam-PE insulation.
   3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
   4. Jacketed with sunlight-resistant, black PVC or PE.
   5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg. C.

D. RG-6/U: NFPA 70, Type CATV or CM.
   1. Quad Shield
   2. Jacketed with black PVC or PE.
   3. Suitable for indoor installations.

E. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
   1. CATV Cable: Type CATV.
   2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
   3. CATV Riser Rated: Type CATVR, complying with UL 1666.
   4. CATV Limited Rating: Type CATVX.

2.05 COAXIAL CABLE HARDWARE
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, O.A.E.:
   1. Belden
   2. Leviton Voice & Data Division.
   3. Siemon Co. (The).

B. Coaxial-Cable Connectors: Type F, 75 ohms.

2.06 TELECOMMUNICATIONS OUTLET/CONNECTORS
A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568-C.1.

B. Outlets: Refer to floor plans for number of ports per faceplate. Coordinate with Architect for faceplate colors.
   1. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
      a. Flush mounting jacks, positioning the cord at a 45-degree angle.
   2. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.07 GROUNDING
A. Comply with requirements in Division 26 Section “Grounding and Bonding for Electrical Systems” for grounding conductors and connectors and the drawings.

B. Comply with TIA-607-B, the NEC, and the AHJ requirements.

2.08 IDENTIFICATION PRODUCTS
A. Comply with TIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Confirm cabling color scheme with Owner prior to purchasing cable.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.09 SOURCE QUALITY CONTROL
A. Testing Agency: Contractor shall evaluate cables.

B. Factory test UTP cables on reels according to TIA-568-C.1.
C. Factory test UTP cables according to TIA-568-C.2.
D. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
E. Cable will be considered defective if it does not pass tests and inspections.
F. Prepare test and inspection reports.

PART 3 EXECUTION

3.01 WIRING METHODS
A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Division 26 Section “Raceway and Boxes for Electrical Systems.”
B. Wiring within Enclosures:
   1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
   2. Install lacing bars and distribution spools.
   3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.02 INSTALLATION OF PATHWAYS
A. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section “Communications Equipment Room Fittings.” Drawings indicate general arrangement of pathways and fittings.
B. Comply with TIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
C. Comply with requirements in Division 26 Section “Raceway and Boxes for Electrical Systems” for installation of conduits and wireways.
D. Install manufactured conduit sweeps and long-radius elbows whenever possible.
E. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room overhead.
   4. Extend conduits 3 inches above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.03 INSTALLATION OF CABLES
A. Comply with NECA 1.
B. General Requirements for Cabling:
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
      a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for UTP at least 49 feet from communications equipment room.
   4. Terminate conductors; Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.

10. In the communications equipment room, install a 10-foot-long service loop on each end of cable.

11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Outdoor Coaxial Cable Installation:
1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.04 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.05 GROUNDING

A. Install grounding according to BICSI TDMM, “Grounding, Bonding, and Electrical Protection” Chapter.

B. Comply with TIA-607-B, the NEC, and the AHJ requirements.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.06 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Administration Class: 2.
   2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

E. Cable and Wire Identification:
   1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
      b. Label each unit and field within distribution racks and frames.
   5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
   6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-A.
   1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.07 FIELD QUALITY CONTROL

A. Contractor shall submit test results to Owner at project completion in paper and electronic format.

B. Perform the following tests and inspections.

2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. UTP Performance Tests:
   a. Test for each outlet. Perform the following tests according to TIA-568-C.1 and TIA-568-C.2:
      1) Wire map.
      2) Length (physical vs. electrical, and length requirements).
      3) Insertion loss.
      4) Near-end crosstalk (NEXT) loss.
      5) Power sum near-end crosstalk (PSNEXT) loss.
      6) Equal-level far-end crosstalk (ELFEXT).
      7) Power sum equal-level far-end crosstalk (PSELFEXT).
      8) Return loss.
      9) Propagation delay.
     10) Delay skew.

6. Coaxial Cable Tests: Conduct tests according to Section 27 41 33 "Master Antenna Television System."

7. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
   a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
   b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.08 DEMONSTRATION

A. Train Owner’s maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION
SECTION 28 0513
CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fire alarm wire and cable.
   2. Identification products.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.

B. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

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

2.02 FIRE ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products as recommended by the fire alarm system manufacturer.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760. Use plenum-rated cable throughout building.

2.03 IDENTIFICATION PRODUCTS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

PART 3 EXECUTION

3.01 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.02 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method:
   1. Cables and pathways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
   2. Fire-Rated Cables: Use of two-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
   3. Signaling Line Circuits: Power-limited fire alarm cables may be installed in the same cable or pathway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated,
spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system’s wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another for supervisory circuits. Color code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

F. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.03 CONNECTIONS

A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.04 FIRESTOPPING

A. Comply with firestopping requirements in Division 07.

B. Comply with TIA-569-C, "Firestopping" Annex A.

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.05 GROUNDING

A. For low-voltage wiring and cabling, comply with requirements in Section 280526 "Grounding and Bonding for Electronic Safety and Security."

3.06 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

END OF SECTION
SECTION 28 3111
DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fire-alarm control unit.
   3. System smoke detectors.
   7. Addressable interface device.
   8. Digital alarm communicator transmitter.

1.02 DEFINITIONS

A. FACP: Fire Alarm Control Panel.

1.03 SUBMITTALS

A. See Section 01 3000 – Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product, including furnished options and accessories.
   1. Include construction details, material descriptions, dimensions, profiles, and finishes.
   2. Include rated capacities, operating characteristics, and electrical characteristics.
C. Shop Drawings: For fire-alarm system.
   1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
   2. Include plans, elevations, sections, details, and attachments to other work.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
   4. Include voltage drop calculations for notification-appliance circuits.
   5. Include battery-size calculations.
   6. Include input/output matrix.
   7. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
   8. Include performance parameters and installation details for each detector.
   9. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
   10. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
   11. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
D. General Submittal Requirements:
   1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
   2. Shop Drawings shall be prepared by persons with the following qualifications:
      a. Trained and certified by manufacturer in fire-alarm system design.
      b. NICET-certified, fire-alarm technician; Level III minimum.
      c. Licensed or certified by authorities having jurisdiction.
E. Qualification Data: For Installer.
F. Field quality-control reports.
G. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
   a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
   b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
   c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
   d. Riser diagram.
   e. Device addresses.
   f. Record copy of site-specific software.
   g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
      1) Equipment tested.
      2) Frequency of testing of installed components.
      3) Frequency of inspection of installed components.
      4) Requirements and recommendations related to results of maintenance.
      5) Manufacturer's user training manuals.
   h. Manufacturer’s required maintenance related to system warranty requirements.
   i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

H. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

1.05 PROJECT CONDITIONS

A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.06 WARRANTY

A. See Section 07 7800 – Closeout Submittals, for additional warranty requirements.

B. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
   1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice/strobe evacuation.

B. Automatic sensitivity control of certain smoke detectors.

C. All components provided shall be listed for use with the selected system.
D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Activate emergency shutoffs for gas and fuel supplies.
8. Record events in the system memory.
9. Activate voice/alarm communication system.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
2. Independent fire-detection and -suppression systems.
3. User disabling of zones or individual devices.
4. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:
1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Display system status on graphic annunciator.

2.03 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fire-Lite Alarms, Inc.; a Honeywell International company.
2. Gamewell - FCI by Honeywell.
3. GE UTC Fire & Security; A United Technologies Company.
6. SimplexGrinnell LP.

B. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
   a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
   c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
   d. The FACP shall be listed for connection to a central-station signaling system service.
   e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 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.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
   1. Pathway Class Designations: NFPA 72, Class B.
   2. Install no more than 100 addressable devices on each signaling-line circuit.
   3. Serial Interfaces:
      a. One dedicated RS 485 port for remote station operation using point ID DACT.
      b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
      c. One USB port for PC configuration.

E. Smoke-Alarm Verification:
   1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
   2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
   3. Sound general alarm if the alarm is verified.
   4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:
   1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
   2. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

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. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

L. 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.

M. Surge Protection:
   1. Install surge protection on normal ac power for the FACP and its accessories.
   2. Install surge protectors recommended by FACP manufacturer. Install on all system wiring external to the building housing the FACP.

N. Alarm Silencing, Trouble, and Supervisory Alarm Reset: Manual reset at the FACP and remote annunciators, after initiating devices are restored to normal.
   1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
   2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
   3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.

O. Trouble Conditions: Trouble conditions shall be non-latching.

P. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
   1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
      a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
      b. Programmable tone and message sequence selection.
      c. Standard digitally recorded messages for "Evacuation" and "All Clear."
      d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
   2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
   3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

2.04 PREACTION SYSTEM

A. Initiate Presignal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a preaction system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

2.05 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.
2.06 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be two-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
   7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
      a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
      b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
      c. Multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).
   3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
   4. Each sensor shall have multiple levels of detection sensitivity.
   5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

### 2.07 HEAT DETECTORS

**A. General Requirements for Heat Detectors**: Comply with UL 521.
1. Temperature sensors shall test for and communicate the sensitivity range of the device.

**B. Heat Detector, Combination Type**: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

**C. Heat Detector, Fixed-Temperature Type**: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

### 2.08 NOTIFICATION APPLIANCES

**A. General Requirements for Notification Appliances**: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
1. Combination Devices: Factory integrated audible and visible devices in a single mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

**B. Visible Notification Appliances**: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
1. **Rated Light Output**:
   a. 15/30/75/110 cd, selectable in the field; as required to meet ADA requirements.
2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished white, if permitted by the Authority Having Jurisdiction.

**C. Voice/Tone Notification Appliances**:
1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the “Notification Appliances” and “Emergency Communications Systems” chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

### 2.09 MAGNETIC DOOR HOLDERS

**A. Description**: Units are equipped for wall or floor mounting as indicated and are complete with matching doornote.
1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

**B. Material and Finish**: Match door hardware.

### 2.10 REMOTE ANNUNCIATOR

**A. Description**: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
1. Mounting: Flush cabinet, NEMA 250, Type 1.
B. Display Type and Functional Performance: Touch-screen graphic annunciator or alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

C. Fire/Mass Notification: Provide remote audio modules and paging microphone within cabinet.

D. Gamewell E3 Series LOC in E3BB-BAA enclosure or approved alternate.

2.11 ADDRESSABLE INTERFACE DEVICE

A. General:
   1. Include address-setting means on the module.
   2. Store an internal identifying code for control panel use to identify the module type.
   3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Control Module:
   1. Operate notification devices.
   2. Operate solenoids for use in sprinkler service.
   3. Operate gas solenoid valve.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:
   1. Address of the alarm-initiating device.
   2. Address of the supervisory signal.
   3. Address of the trouble-initiating device.
   4. Loss of ac supply.
   5. Loss of power.
   6. Low battery.
   7. Abnormal test signal.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.02 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
   1. Devices placed in service before all other trades have completed cleanup shall be replaced.
   2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

C. Manual Fire-Alarm Boxes:
   1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
   3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Smoke- or Heat-Detector Spacing:
   1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
   2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
   3. Smooth ceiling spacing shall not exceed 30 feet.
   4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
   5. HVAC: Locate detectors not closer than 60 inches from air-supply diffuser or return-air opening.
   6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
   1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and speakers on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm speaker and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

K. Installation of Detectors: Detectors shall not be installed until all work of all other trades is complete, per NFPA 72.

L. Remote Power Supplies and/or Booster Panels: Panels shall not be located in finished spaces. Provide a smoke detector at each panel location, if not already indicated on the drawings. Provide 120V circuit from nearest available spare emergency circuit, if not already indicated on drawings.
3.03 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
   1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   1. Smoke dampers in air ducts of designated HVAC duct systems.
   2. Electronically locked doors and access gates.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.05 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.06 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform the following tests and inspections:
   1. Visual Inspection: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
      b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.


   3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

   4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

   5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

   6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.07 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

3.08 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION
SECTION 31 0000
EARTHWORK

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Clearing, grubbing and site preparation

B. Removal and disposal of debris

C. Handling, storage, transportation, and disposal of excavated material

D. Sheeting, shoring, bracing and protection work

E. Pumping and dewatering as required or necessary

F. Backfilling

G. Pipe embedment

H. Construction of fills and embankments

I. Excavation for buildings & structures

J. Pavement Subgrade preparation

K. Trench Stabilization

L. Final grading

M. Slope Stabilization

N. Appurtenant work

1.2 REFERENCES

A. AASHTO – American Association of State Highway and Transportation Officials

B. ASTM – American Society for Testing and Materials
   1. C33 – Concrete Aggregates
   2. C136 – Sieve Analysis of Fine and Coarse Aggregates
   3. D698 – Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. Rammer and 12-Inch Drop
   4. D1241 – Material for Soil Aggregate Subbase, Base and Surface Courses
   5. D1557 – Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
   6. D4253 – Test Methods for Maximum Index Density of Soils and Unit Weight of Soils Using a Vibratory Table
   7. D4254 – Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
   9. D6938 – Test Method for In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (Shallow Depth)

C. ACI – American Concrete Institute
1. 229 – Controlled Low-Strength Materials

D. CABO/ANSI – Council of American Building Officials/American National Standards Institute
   1. A117.1 – Accessible and Useable Buildings and Facilities Standards

E. CDOT – Colorado Department of Transportation

F. OSHA – Occupational Safety and Health Administration
   1. Part 1926 – Safety and Health Regulations for Construction

1.3 SUBMITTALS

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

B. Product Data: Submit on all products or materials supplied herein

C. Test Reports: Indicate supplier, sieve analysis, optimum moisture content and density in accordance with ASTM D698 if appropriate for crushed rock or gravel, pipe embedment and material for fills and embankment

1.4 REGULATORY REQUIREMENTS

A. Burning will not be allowed on-site. Comply with all applicable codes, regulations, and laws.

B. Comply with applicable requirements of CABO/ANSI A117.1 for accessibility requirements related to walks, ramps, parking areas, drives, curb ramps, etc.

C. Obtain and comply with all requirements of Town of Berthoud and CDPHE Stormwater and/or Groundwater Discharge Permits, as required.

D. For public improvements only, in the event of a conflict between municipal standards and this specification, municipal standards for products and installation will govern.

E. Excavation work will be performed in compliance with Town of Berthoud and current OSHA requirements.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Protect adjacent structures and surrounding areas from damage during excavation, filling, and backfilling

B. Protect work from erosion or other similar types of damage until the project has been accepted. Leave protection in place for subsequent contractors’ use.

C. Do not backfill or construct fills during freezing weather. Backfill or construct fills only when temperature is 35°F and rising

D. Do not use frozen materials, snow, or ice in any backfill or fill area

E. Do not backfill or construct fill on frozen surfaces

F. Protect excavated material from becoming frozen

G. Do not backfill or construct fills or embankments during periods of heavy rainfall or precipitation when soil moisture conditions will not allow proper compaction to be achieved

H. Do not remove trees from outside excavation or fill areas unless authorized by the Owner; protect from permanent damage by construction activities

I. Provide temporary bridges for roadways, walkways, driveways, etc.
1.6 QUALITY ASSURANCE

A. All imported material to be free of hazardous and organic wastes, “clean” as defined by EPA, and approved for its intended use by the Owner or project Geotechnical Engineer.

PART 2 PRODUCTS

2.1 MATERIALS

A. General - Soil materials, whether from sources on or off the site must be approved by the Geotechnical Engineer as suitable for intended use and specifically for required location or purpose.

B. Classification of Excavated Materials:
   1. No classification applies. Remove and handle all excavated materials regardless of its type, character, composition, condition, or depth. This includes all material that is not classified as rock excavation as described in Paragraph 2.1.B.2 Rock Excavation is included herein.
   2. Rock Excavation: classified as removal of solid material that by actual demonstration, in the Engineer's opinion, cannot be reasonably loosened or ripped by either a single-tooth, hydraulically operated ripper mounted on a crawler tractor in good condition rated at a minimum 300 flywheel horsepower or excavated with a minimum 325 flywheel horsepower hydraulic excavator in good condition equipped with manufacturer's standard boom, two rippers and rock points, or
      a. Material that for convenience or economy is loosened by drilling, or the use of pneumatic tools, is not considered rock excavation
      b. Removal of boulders larger than 1/2 cubic yard will be classified as rock excavation, if drilling or breaking them apart with power operated hammer, hydraulic rock breaker, expansive compounds, or similar means is both necessary and actually used for their removal
      c. Contractor to inform Engineer when rock excavation is required prior to performing Work
      d. Contractor to provide accurate records of excavated rock to confirm quantity of rock excavated.
   3. Excavation of rock that cannot be excavated as outlined above will be considered rock excavation and may require alternative means that may include drilling, blasting, or expansive compounds.
   4. Waste Materials:
      a. Waste materials are considered unacceptable materials for compaction or placement fill. Site fills will not include environmental pollutants, hazardous substances or waste, hazardous products or by-products.
      b. Transport and properly dispose of any rubble and waste materials found in excavation off the Owner’s property
      c. If hazardous, transite or asbestos containing materials are found in excavation, stop work immediately and notify the Owner within one hour of discovery. Comply with special handling requirements.

C. Fills and Embankments
   1. To the maximum extent practical use excess earth from onsite excavation for fills and embankments.
   2. Free from rocks or stones larger than 12 inch in greatest dimension and free from brush, stumps, logs, roots, debris, and organic and other deleterious materials
   3. Fill and embankment material must be acceptable to Engineer
   4. No rocks or stones larger than 6 inch in upper 18 inches of fill or embankment. Where allowed, distribute rocks and stones through the fill to not interfere with compaction.

D. Imported Fill for Fills and Embankments:
   1. The Contractor is responsible for obtaining additional material for fills and embankments as necessary to meet the requirements shown on the Drawings.
   2. Imported fill conforming to the following:
      a. Gradation (percent finer by weight ASTM C136): 3” – 100% passing, No. 4 Sieve – 50-100% passing, and No. 200 Sieve – 35% passing (maximum)
      b. Liquid Limit: 40 (maximum), Plasticity Index: 20 (maximum), Group Index: 10 (maximum)

E. Structural Fill
   1. Imported structural fill, such as CDOT Class 1 Structural Backfill, conforming to the following:
a. Gradation: free-draining granular material with 100% passing the 2-inch sieve and less than 20% passing the No. 200 sieve
b. Liquid Limit: 30 (maximum), Plasticity Index: 6 (maximum)

F. Topsoil
1. Topsoil is defined as fertile, friable, natural loam, surface soil, reasonably free of subsoil, clay lumps, brush, weeds and other litter, and free of rocks, stumps, stones larger than 2 inches in any dimension, and other extraneous or toxic matter harmful to plant growth for areas to be seeded or planted. Coordinate testing requirements with Landscape Architect and Owner.
2. Clean topsoil free of plants and seeds will be spread to 4-inch minimum depth or as specified by Drawings, whichever is greater.

G. Grubbings
1. Grubbings are defined as the first 1 inch of surface vegetation and topsoil consisting of primarily existing grass groundcover free of roots, brush, and other objectionable material and debris.
2. Reuse grubbing and surface topsoil containing plants and seeds in designated revegetation areas only.

H. Pipe Embedment: Graded gravel
1. Comply with Town of Berthoud, requirements for pipe embedment for public utilities.
2. 1-1/2" Washed rock

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<th>Percent Passing by Weight</th>
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3. 3/4" – 1" Crushed rock – AASHTO 57/67

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4. Well-Graded Sand

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5. Squeegee

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<td>No. 50</td>
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6. Drain Gravel
   a. Crushed rock, granular material with a maximum size of 1-1/2 inch.
   b. Minimum 50% passing No. 4 sieve, maximum 5% retained on No. 200 sieve

I. Compacted Trench Backfill
   1. Job excavated material finely divided, free of debris, organic material, and stones larger than 6 inches in greatest dimension without masses of moist, stiff clay, or topsoil
   2. In upper 18 inches, no rock or rock excavated detritus, larger than 6 inches except with specific approval from Geotechnical Engineer.
   3. No rock greater than 3 inches in greatest dimension within 3 feet of top of pipe
   4. Graded gravel: as specified or shown on Drawings for pipe embedment

J. Coarse Base Rock
   1. Granular material, maximum 3 inches, less than 10% passing 1-inch sieve.
   2. Free of trash, clay and dust
   3. Compaction as specified by Geotechnical Engineer

K. Road Base
   1. Will meet ASTM specification for Class II aggregate base and CDOT Class 6 gradation

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<td>No. 4</td>
<td>30-65</td>
</tr>
<tr>
<td>No. 8</td>
<td>22-55</td>
</tr>
<tr>
<td>No. 200</td>
<td>3-12</td>
</tr>
</tbody>
</table>

2.2 ACCESSORIES

A. Controlled Low Strength Material (Flow Fill)
   1. Comply with Town of Berthoud requirements and ACI 229 for the use of flowable fill within the right-of-way or for public utility trench backfill.
   2. Product will be a lean, sand-cement slurry, “flowable fill” or similar material with a 28-day unconfined compressive strength between 50 and 200 psi.

B. Non-woven geotextile fabric
   1. Needle-punched nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. Product must be inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids. Product must meet AASHTO M288-06 Class 3 for elongation > 50%.
      a. Mirafi 140N or accepted substitution

PART 3 EXECUTION

3.1 EXAMINATION

A. Field verify the location of all underground utilities, pipelines and structures prior to excavation

3.2 PERFORMANCE — GENERAL

A. Contractor to verify quantities of cuts and fills and perform all earthwork required to meet the grades as shown on the Drawings, including but not limited to, additional import or export required to handle compaction, building and pavement subgrade preparation, and pipe bedding.
B. Perform work in a safe and proper manner with appropriate precautions against hazard

C. Provide adequate working space and clearances for work performed within excavations and for installation and removal of utilities

D. Contain all construction activity on the designated site and within the limits of work. Cost of restoration offsite will be the responsibility of the Contractor

E. Maintain service to pipelines and utilities indicated on Drawings during construction

3.3 PREPARATION

A. Clearing and Grubbing
   1. Clear all site areas within the limits of work of grasses, roots, brush, and other objectionable material and debris.
   2. Strip subgrade for fills and embankments of surface vegetation, sod, tree stumps and organic topsoil. Strip and stockpile all on-site material meeting the topsoil definition for all areas receiving grading where shown on Drawings
   3. Remove all waste materials from site and dispose. Stockpile all acceptable grubblings for reuse in revegetation areas.
   4. Remove and dispose of tree stumps and roots over 3 inches in diameter to a minimum depth of 18 inches below the natural surface or 5 feet below finished surface level, whichever is lower.
   5. Remove debris including all demolished trees, underbrush, stumps, roots and other combustible materials from site and dispose of off-site; on-site burning is not permitted
   6. Backfill all excavated depression include grub holes with approved material

B. Preservation of Trees
   1. Do not remove trees outside fill or excavated areas, except as authorized by Engineer
   2. Protect trees and their roots within the drip line that are to remain from permanent damage by construction operation
   3. Trim standing trees in conflict with construction operations as directed by Owner and Landscape Architect.

C. Topsoil Stripping
   1. Strip onsite material meeting the topsoil definition to minimum depth of 4 inches from areas to receive grading as shown on Drawings.
   2. Stockpile topsoil in areas designated by Owner and indicated on Drawings where it will not interfere with construction operations and activities and existing facilities
   3. At the completion of work in each area, place and grade topsoil to maintain gradient as indicated and required. Roughen surface as required for erosion control.

D. Waste and Debris
   1. Stockpile all acceptable grubbing for reuse in native revegetation areas
   2. Remove and dispose of all waste materials and debris from clearing, grubbing, stripping and demolition off site

E. Stockpiles
   1. Segregate materials suitable for the following:
      a. Topsoil
      b. Embankments and fills
      c. Backfill
      d. Spoils and waste only
   2. No excavation will be deposited or stockpiled at any time so as to endanger stability of banks or structures, health of trees and shrubs to be protected, or portions of the Work, either by direct pressure or indirectly by overloading banks contiguous to the operation
   3. Stockpile soil materials away from edge of excavations
   4. Do not obstruct or prevent access to roads, driveways, ditches, natural drainage channels, and utility control devices
5. If in result of adjacent structures, easement limitations, or other restrictions sufficient storage is not available within Project limits, Contractor will arrange for off-site areas for stockpiling and for moving material to and from the storage area at no additional cost to the Owner

3.4 PROTECTION OF EXISTING UTILITIES AND STRUCTURES

A. Excavation and backfill operations will be performed in such a manner to prevent cave-ins of excavations or the undermining, damage or disturbing of existing utilities and structures or of new work.

B. Backfill will be placed and compacted so as to prevent future settlement or damage to existing utilities and structures and new work

C. Any excavations improperly backfilled or where settlement occurs will be reopened to the depth required then refilled with approved materials and compacted, and the surface restored to the required grade and condition, at no additional costs to the Owner

D. Any damage due to excavation, backfilling, or settlement of the backfill, or injury to persons or damage to property occurring as a result of such damage will be the responsibility of the Contractor. All costs to repair such damage, in a manner satisfactory to the Engineer, will be borne by the Contractor at no additional expense to the Owner

3.5 DEWATERING

A. General

1. All dewatering activities in accordance with all federal, state, and local regulations regarding site drainage, dewatering, and erosion and sediment control including permitting requirements

2. Design and provide dewatering system using accepted and professional methods consistent with current industry practice to eliminate water entering the excavation under hydrostatic head from the bottom and/or sides. Design system to prevent differential hydrostatic head, which would result in floating out soil particles in a manner, termed as a “quick” or “boiling” condition. System will not be dependent solely upon sumps and/or pumping water from within the excavation where differential head would result in a quick condition, which would continue to worsen the integrity of the excavation’s stability

3. Provide and maintain adequate dewatering equipment including power supply, if necessary, to remove and dispose of surface and groundwater entering excavations, trenches, and other parts of the Work

4. Provide dewatering system of sufficient size and capacity to prevent ground and surface water flow into the excavation and to allow all Work to be installed in a dry condition

5. Control groundwater in a manner that preserves strength of foundation soils, does not cause instability or raveling of excavation slopes, and does not result in damage to existing structures. Where necessary to these purposes, lower water level in advance of excavation, utilizing wells, wellpoints, jet educators, or similar positive methods

6. Keep each excavation dry during subgrade preparation and continually thereafter until the structure to be built or the pipe to be installed is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result

7. Dewater excavations which extend to or below groundwater by lowering and keeping the groundwater level beneath such excavation at least 12 inches below the bottom of the excavation

8. Design, furnish, install, test, operate, monitor and maintain dewatering system of sufficient scope, size and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of groundwater and permit excavation and construction to proceed on dry, stable subgrades

9. Divert surface water or otherwise prevent it from entering excavated areas or trenches to the extent practical without damaging adjacent property

10. Maintain all drainage pipes, keep clean and free of sediment during construction and final cleanup

11. Open pumping with sumps and ditches will be allowed, provided it does not result in boils, loss of fines, softening of the ground, or instability of slopes

12. No additional payment will be made for any supplemental measures to control seepage, groundwater, or artesian head

13. Dewatering to surface waterways requires Colorado Department of Public Health and Environment dewatering permit. Contractor must obtain dewatering permit and comply with discharge requirements therein, including water treatment prior to discharge, if necessary
B. Design
1. Contractor will be responsible for the accuracy of the Drawings, design data, and operational records required.
2. Contractor will be solely responsible for the design, installation, operation, maintenance, and any failure of any component of the system.

C. Damages
1. Contractor will be responsible for and will repair without cost to the Owner any damage to work in place, or other contractor’s equipment, utilities, residences, highways, roads, railroads, private and municipal well systems, adjacent structures, natural resources, habitat, existing wells, and the excavation including, damage to the bottom due to heave and including but not limited to, removal and pumping out of the excavated area that may result from Contractor’s negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.
2. Remove subgrade materials rendered unsuitable by excessive wetting and replace with approved backfill material at no additional cost to the Owner.

D. Maintaining Excavation in Dewatered Condition
1. Dewatering will be a continuous operation. Interruptions due to power outages, or any other reason will not be permitted.
2. Continuously maintain excavation in a dry condition with positive dewatering methods during preparation of subgrade, installation of pipe, and construction of structures until the critical period of construction and/or backfill is completed to prevent damage of subgrade support, piping, structure, side slopes, or adjacent facilities from flotation or other hydrostatic pressure imbalance.
3. Provide standby equipment on site, installed, wired, and available for immediate operation if required to maintain dewatering on a continuous basis in the event any part of the system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional cost to Owner.
4. System maintenance will include supervision by personnel skilled in the operation, maintenance, and replacement of system components, and any other work required to maintain excavation in dewatered condition.

E. System Removal
1. Remove dewatering equipment from the site, including related temporary electrical service.
2. Wells will be removed or cut off a minimum of 3 feet below final ground surface, capped, and abandoned in accordance with regulations by agencies having jurisdiction.

3.6 SHEETING, SHORING AND BRACING
A. All sheeting, shoring and bracing in accordance with OSHA and IBC requirements.
B. Prevent undermining and damage to all structures, buildings, underground facilities, pavements and slabs.
C. Contractor will responsible for obtaining all required permits or easements for encroachments into the public right-of-way and for coordinating any encroachments onto adjacent properties.
D. If sheet pile cut off walls are required, submit design calculations, stamped by a Colorado licensed Professional Engineer.
E. Contractor will be solely responsible for proper design, installation, operation, maintenance, and any failure of any system component.
1. Engineer review of Contractor’s design and data does not relieve the Contractor from full responsibility for errors or from the entire responsibility for complete and adequate design and performance of the sheeting, shoring and bracing system.
F. Provide proper and substantial sheeting, shoring, and bracing, in accordance with OSHA Standards as required, to prevent caving or sliding, to protect workmen and the Work, and to protect existing structures and facilities.
G. Design, furnish, build, maintain and subsequently remove, to extent required a system of temporary supports for cut and cover, open cut, temporary bypass road, or trench excavations, including bracing, dewatering, and all associated items to support the sides and ends of excavations where excavation slopes may endanger in-place or proposed improvements, extend beyond construction right-of-ways or as otherwise specified or indicated in the Drawings
   1. Design and build sheeting, shoring, and bracing to withstand all loads that might be caused by earth movement or pressure
   2. Design and build sheeting, shoring and bracing to be rigid, maintain shape and position under all circumstances.

H. Design excavation support system and components for the following to allow safe and expeditious construction of permanent structures without movement/settlement of the ground and to prevent damage to or movement of adjacent buildings, structures, other improvements and underground facilities
   1. To support lateral earth pressures
   2. Loads from utilities, traffic, construction, buildings and surcharge loads

I. Provide sheeting, shoring and bracing equipment and materials onsite prior to start of excavation in each section, making adjustments as required to meet unexpected conditions

J. Contractor will make his own assessment of existing conditions including adjacent property, the possible effects of his proposed temporary works and construction methods, and will select and design support systems, methods, and details as will assure safety to the public, adjacent property, and the completed Work.

K. Employ caution in areas of underground facilities, which will be exposed by hand or other excavation methods acceptable to Owner or Engineer.

L. Space and arrange sheeting and bracing as required to exclude adjacent material and according to the stability of excavation slopes

M. Do not pull trench sheeting before backfilling

N. Do not brace sheeting left in place against the pipe, but support it in a manner that precludes concentrated loads or horizontal thrusts on pipe

O. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment is completed

P. Damages
   1. Contractor will document and all existing damage to adjacent facilities and submit written documentation to Owner and Engineer prior to performing any excavation. Documentation will include written description of existing damages, measurements, diagrams, maps and associated photographs
   2. Repair all damage resulting from excavation and remove and place any existing structure or underground facility damaged during shoring and sheeting and all undermined pavements with Owner-approved equal, concrete or asphalt, at no cost to the Owner.

3.7 TRENCH STABILIZATION

A. Thoroughly compact and consolidate subgrades for concrete structures, precast structures, and utility trench bottoms so they remain firm, dense and intact during required construction activities

B. Remove all mud and muck during excavation

C. Reinforce subgrades with crushed rock or gravel if they become mucky during construction activities

D. Finished elevation of stabilized subgrades are to be at or below subgrade elevations indicated on Drawings
E. Allow no more than ½ inch depth of mud or muck to remain on trench bottoms when pipe bedding material is placed thereon

F. Scarify trench subgrade to a depth of 6 to 8 inches before compaction

3.8 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 0.10 foot

B. Remove existing unsuitable/uncompacted fill, old foundations, rubble/debris, soft or otherwise unsuitable material, and replace with suitable material in excavation

C. Extend excavations to a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction and inspections

D. Trim to neat lines where details call for concrete to be deposited against earth

E. Excavate by hand in areas where space and access will not permit use of machines

F. Provide dewatering and temporary drainage as required to keep excavations dry.

G. Reshape subgrade and wet as required

H. Notify Geotechnical Engineer when structure excavation has reached designated depth. Do not proceed with structure construction until excavation is approved by Geotechnical Engineer.

I. Per the geotechnical report, for overexcavation and recompaction areas at structures, soils will be excavated to a depth of at least 3 feet below existing grade or the bottom of all floor slabs on grade. If the existing subgrade soils are moisture conditioned, subexcavation to an approximate depth of two feet, moisture conditioning and re-compacting the in-place soils to an additional depth of 12 inches, and replacement of the sub-excavated soils with moisture conditioning and compaction is recommended. The subexcavation will be configured at a minimum side slope inclination of 1(horizontal):1(vertical) from the toe of the subexcavation slope. The toe of the subexcavation slope will be no closer than 5 feet outside the outermost edge of all concrete footings or building boundaries laterally, whichever is larger. Slope will continue to the proposed surface grades.

3.9 PAVEMENT OVEREXCAVATION AND SUBGRADE PREPARATION

A. Excavate subgrade for asphalt pavement areas per the lines, grades, and dimensions indicated on Drawings within a tolerance of plus or minus 0.10 foot. Excavate subgrade for concrete pavement areas per the lines, grades, and dimensions indicated on Drawings within a tolerance of plus or minus 0.05 foot.

B. Overexcavate, moisture conditioning of the upper three feet (3') of all existing soil as required under pavement areas, slabs, curbs and walks to meet the moisture and compaction specifications herein. Double application lime-treatment stabilization of the upper 12-inches is required.

C. Extend subgrade preparation a minimum of one foot beyond back of proposed pavement, slabs, curbs and walks.

D. Extend subgrade preparation a minimum of two feet beyond back of proposed structure foundation limit.

E. Proof roll with a pneumatic tire equipment with a minimum axle load of 18 kips per axle a maximum of 24 hours prior to paving to locate any soft spots that exhibit instability and deflection beyond subgrade tolerances listed above. Areas that are observed to have soft spots in the subgrade, where deflection is not uniform or is excessive as determined by the Geotechnical Engineer, will be ripped, scarified, dried or wetted as necessary and recompacted to the requirements for density and moisture at the Contractor’s expense. After recompaction, these areas will be proof rolled again and all failures again corrected at the Contractor’s expense.
F. If the Contractor fails to place the sub base, base course, or initial pavement course within 24 hours or the condition of the subgrade changes due to weather or other conditions, proof rolling and correction will be performed again at the Contractor's expense.

3.10 FILLS AND EMBANKMENTS

A. Using suitable approved materials, shape, trim, and finish cut slopes to conform with contours and elevations indicated on Drawings

B. Suitable materials will consist of excavations or borrow areas
   1. Borrow
      a. Borrow areas will be arranged by Contractor at no additional cost to Owner and will be subject to approval by Engineer or Geotechnical Engineer
      b. Includes all topsoils and fill materials from approved offsite locations

C. A maximum lift thickness of 6-inches should be observed for subexcavated and replaced soil. A maximum treatment of 12-inches should be observed for soil moisture treated and compacted in-place. Will be placed on subgrades approved by Engineer or Geotechnical Engineer

D. Will not be placed on frozen surface. Do not place snow, ice or frozen materials in fill

E. Level and roll subgrade so surface materials will be compact and bond with the first layer of fill or embankment
   1. Plow and scarify subgrade to a minimum depth of 6 inches until uniform and free of large clods

F. Place in horizontal layers at maximum uncompacted depth per compaction specifications herein.

G. Spread and level material deposited in piles and windrows before compacting

H. Thoroughly compact each layer by rolling or other means acceptable to Geotechnical Engineer to meet the moisture and compaction specifications herein.

I. Alter compaction methods if material fails to meet specified density

J. Where a trench passes through a fill or embankment, place and compact fill or embankment to 12 inch above the top of the pipe before excavating the trench

K. Add water and harrow, disc, blade, or otherwise work each layer to obtain the uniform moisture content and adequate compaction

L. Refer to geotechnical report for additional requirements for fill and embankment preparation requirements.

3.11 COMPACTION

A. Place backfill and fill materials in layers not more than 6 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill materials evenly on all sides of structures to required elevations. Place backfill and fill uniformly along the full length of each structure as described herein.

C. Refer to geotechnical report for additional requirements for site development material, subexcavation, compaction and related earthwork operations.

D. Percentage of Maximum Dry Density Requirements: Moisture treat and compact soil to not less than the following percentages of maximum dry density and to within the specified moisture content range of optimum moisture content according to ASTM D698 as follows:
<table>
<thead>
<tr>
<th>Surface Improvement</th>
<th>Compaction %</th>
<th>Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures</td>
<td>98%</td>
<td>-2 to +2</td>
</tr>
<tr>
<td>Paved Areas</td>
<td>95%</td>
<td>-2 to +2</td>
</tr>
<tr>
<td>Synthetic Turf Fields</td>
<td>95%</td>
<td>-2 to +2</td>
</tr>
<tr>
<td>Utility Trenches</td>
<td>95%</td>
<td>-2 to +2</td>
</tr>
<tr>
<td>Lawns or Unpaved Areas</td>
<td>90%</td>
<td>-2 to +2</td>
</tr>
<tr>
<td>Public Right-of-way</td>
<td>Per municipal standards</td>
<td></td>
</tr>
</tbody>
</table>

1. Do not deposit or compact tamped or otherwise mechanically compacted backfill if frozen or if in water.
2. Take particular care to compact backfill which will be beneath slabs, pipes, drives, roads, parking areas, curb, gutters, or other surface construction.

3.12 BORROW OR SPOIL AREA

A. Obtain suitable material required to complete fill and embankments from excavation, on-site areas.

B. The location, size, shape, depth, drainage, and surfacing of borrow or spoil pits will be acceptable to Owner.

C. Make all areas regular in shape with graded and surfaced side and bottom slopes when completed.

D. Cut side slopes not steeper than 1:1 and uniform for the entire length of any one side.

E. Final grade disturbed areas of borrow to uniform slope (maximum slope = 4:1, minimum slope = 50:1).

F. Use material free of debris and deleterious material.

G. Contractor is responsible for compliance with Colorado Discharge Permit System and local erosion control permitting requirements for any and all onsite and offsite, disturbed spoil and borrow areas. Upon completion of spoil and/or borrow operations, clean up spoil and/or borrow areas in a neat and reasonable manner to the satisfaction of the offsite property owner, Owner and Engineer.

3.13 DISPOSAL OF EXCESS EXCAVATED MATERIALS

A. Use excess excavated materials in fills and embankments as indicated on the Drawings to the extent needed. Coordinate with Owner and Engineer on locations for excess material placement.

B. The Contractor is responsible for disposing of all excess excavated materials from the site to a location approved by the Owner or Engineer and permitted with the local authorities.

C. At the Owner’s discretion and with the Engineer’s approval, suitable excess excavated materials from onsite may be disposed offsite at locations directed by Owner or specified on the Drawings.

D. Remove debris, junk, broken concrete, broken asphalt, rock, stones, stumps, logs, roots, and other unsuitable material from the site and dispose of it.
3.14 BLASTING

A. Blasting or other use of explosives is not permitted without Town of Berthoud approval

3.15 TRENCH EXCAVATION

A. Establish alignment and grade or elevation from offset stakes provided by the Contractor’s surveyor.

B. Excavate trenches so pipes can be laid straight at uniform grade without dips or bumps, between the terminal elevations indicated on the Drawings

C. Comply with pipe specification sections regarding vertical and horizontal alignment and maximum joint deflection

D. Where grades or elevations are not fixed on the Drawings, excavate trenches to provide a minimum depth of backfill cover over the top of pipe as follows. Coordinate depth of cover with utility owners. Increase depth as required by utility owner and at crossings. Minimum depths are:
   1. 2.0 feet for drainage piping
   2. 2.5 feet for gas piping
   3. 2.5 feet for electric, telecom, and fiber optic conduit
   4. 2.0 feet for irrigation piping
   5. 4.0 feet for sanitary sewer
   6. 4.5 feet for water piping
   7. Increase depth as required at vertical curves and for clearance beneath existing pipes, conduits, drains, drainage structures, or other obstructions encountered at normal pipe grades

E. Measure pipe cover depth vertically from top of pipe to finished ground or surface elevation

F. Do not open more trench in advance of pipe laying than is necessary to expedite the work; not more than 200 feet

G. Total length of open trench will be limited to 200 feet unless otherwise approved by the Engineer

H. Except where tunneling or boring is indicated on the Drawings, specified, required by jurisdictional agency or permitted by Engineer, excavate trenches by open cut from the surface

I. Limiting trench widths
   1. Excavate to a width which will provide adequate working space and pipe clearances for proper pipe installation, jointing, embedment
   2. If needed to reduce earth loads to prevent sliding, cut banks back on slopes which extend not lower than 1 foot above the top of the pipe
   3. Stipulated minimum clearances are minimum clear distances, not minimum average distances
   4. Maximum trench width from six inches above the top of pipe to trench bottom is the pipe outside diameter plus 24 inches
   5. Limiting trench widths and permissible clearances from 6 inches above top of pipe to trench bottom for installed pressure and non-pressure piping

<table>
<thead>
<tr>
<th>Pipe Size (inch)</th>
<th>Minimum Trench Width</th>
<th>Maximum Trench Width</th>
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<tbody>
<tr>
<td>3</td>
<td>1' 6&quot;</td>
<td>2' 6&quot;</td>
</tr>
<tr>
<td>4</td>
<td>1' 6&quot;</td>
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<tr>
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<td>3' 0&quot;</td>
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<td>16</td>
<td>2' 8&quot;</td>
<td>3' 8&quot;</td>
</tr>
<tr>
<td>18</td>
<td>3' 0&quot;</td>
<td>4' 0&quot;</td>
</tr>
<tr>
<td>Pipe Size (inch)</td>
<td>Minimum Trench Width</td>
<td>Maximum Trench Width</td>
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</tr>
<tr>
<td>24</td>
<td>3' 6&quot;</td>
<td>4' 6&quot;</td>
</tr>
<tr>
<td>36</td>
<td>4' 6&quot;</td>
<td>5' 0&quot;</td>
</tr>
</tbody>
</table>

6. If the width of the lower portion of the trench exceeds the maximum permitted, provide special pipe embedment, or concrete encasement as required by loading conditions

7. No excessive trench widths will be allowed to avoid the use of sheeting or shoring and bracing

J. Trench Side Walls
1. Will be sloped, shored, sheeted, braced, or otherwise supported by means of sufficient strength to protect workmen in accordance with applicable rules and regulations established for construction by the federal, state, and local ordinances and regulations
2. Sheet and brace where necessary and as specified herein
3. Excavate without undercutting

K. Trench Bottom
1. Will be thoroughly protected and maintained when suitable natural materials are encountered
2. Will be thoroughly compacted and in approved condition prior to placing gravel bedding, if required
3. Where in earth, trench bottoms for 6 inches and smaller pipe may be excavated below pipe subgrade and granular embedment provided or the trench may be graded to provide uniform and continuous support between bell holes or end joints of the installed pipe at the Contractor's option
4. Whenever so directed by Engineer, excavate to such depth below grade as Engineer directs and bring the trench bottom to grade with such material approved by Engineer
5. Do not allow any part of bells or couplings to contact the trench bottom, walls, or granular embedment when pipe is joined
6. PVC pipe will not be laid directly on trench bottom

L. Mechanical excavation
1. Do not use where its operation would damage buildings, culverts, or other existing property, structures, or utilities above or below ground; hand excavate only in such areas
2. Use mechanical equipment of a type and design which can be operated to provide the following:
   a. Rough trench bottom to a controlled elevation
   b. Uniform trench widths and vertical sidewalls are obtained from 1 foot above the top of the installed pipe to the bottom of the trench
   c. Trench alignment is such that pipe is accurately laid to specified alignment and is centered in the trench with adequate clearance between pipe and trench sidewalls
3. Do not undercut trench sidewalls
4. Recompact trench bottom disturbed by bucket teeth prior to placement of embedment material

M. Except as otherwise required, excavate trenches below the underside of pipes as indicated in the Drawings to provide for installation of granular embedment pipe foundation material

N. Whenever so directed by Engineer, excavate to such depth below grade as Engineer directs and bring the trench bottom to grade with such material as Engineer may direct

O. For unstable soils, provide concrete or other bedding as directed by Engineer

P. Do not allow any part of bells or couplings to contact the trench bottom, walls, or granular embedment when pipe is joined

Q. Cuts in existing surface construction
1. No larger than necessary to provide adequate working space
2. Cut a clean groove not less than 1½ inch deep along each side of trench or around perimeter of excavation area
3. Remove pavement and base pavement to provide shoulder not less than 6 feet wide between cut edge and top edge of trench
4. Do not undercut trenches, resulting in bottom trench width greater than top widths
5. Make pavement cuts to and between straight or accurately marked curved lines parallel to trench centerline or limits of excavation
6. Remove pavement for connections to existing lines or structures only to the extent required for the installation
7. Replace the pavements between saw cuts to match original surface construction

3.16 PIPE EMBEDMENT

A. Embed pipes above and below the bottom of pipe as indicated on the Drawings and as specified herein

B. Granular embedment
   1. Spread and surface grade granular embedment to provide continuous and uniform support beneath pipe at all points between pipe joints.
      a. Level bottom layer at proper grade to receive and uniformly support pipe barrel throughout length
      b. Barrel of pipe will have a bearing for its full length
   2. Form depressions under each joint to permit the proper jointing. No part of joint will be in contact with trench when pipe is placed in position
   3. After grading, aligning, and placing pipe in final position, and shoring home, deposit and compact sufficient embedment under and around each side of the pipe to hold the pipe in proper position and alignment during subsequent operations
   4. Place and compact embedment material uniformly and simultaneously on both sides of pipe to prevent displacement
   5. Complete embedment promptly after jointing operations and approval to proceed by Engineer
   6. Granular embedment compaction by slicing with shovel or vibrating
      a. Maximum uncompacted thickness of layers: 6 inch
   7. Compacted embedment will be compacted to 90 percent maximum density per ASTM D1557
      a. Maximum uncompacted depth thickness of horizontal layers: 8 inch

C. Arch and concrete encasement
   1. Include in locations indicated on Drawings or where over-width trench conditions need correction as approved by Engineer
   2. Install and form as indicated on Drawings or as specified
   3. Concrete will have a 28-day minimum 3,000 psi compressive strength

D. Do not backfill until tests and inspections have been made and backfilling is authorized by Engineer. Use care in backfilling to avoid damage or displacement of pipe systems

3.17 TRENCH BACKFILL

A. Backfilling will be conducted in a continuous manner to prevent damage to the pipe and its coating and kept as close to the pipe laying operation as possible. Backfilling procedures will be in accordance with additional requirements, if any, of local authorities or private right-of-way agreements.

B. Compacted backfill
   1. Provide full depth of trench above embedment at all locations
   2. Beneath pavements, surfacing, driveways, curbs, gutters, walks or other surface construction or structures
   3. In street or highway shoulders
   4. Beneath fills and embankments

C. Where the trench for one pipe passes beneath the trench of another pipe, compact the backfill for the lower trench to the bottom of the upper trench

D. Site excavated materials
   1. Place job excavated materials in 6 inches maximum uncompacted thickness, uniform layers
   2. Increased layer thickness may be permitted for incohesive material if Contractor demonstrates to Engineer's satisfaction that specified compacted density will be achieved
   3. Use methods and equipment appropriate to the material to be compacted to prevent transmission of damaging shocks to pipe
4. Thoroughly compact each layer to meet the moisture and compaction specifications herein.

E. Graded gravel
   1. Deposit in uniform layers of 9 inches maximum uncompacted thickness
   2. Compact with suitable vibrating roller or platform vibrator to not less than 70 percent relative density per ASTM D4253/D4254

F. Uncompacted backfill
   1. Compaction of backfill above pipe embedment in locations other than those specified, is required only to prevent future settlement
   2. May be placed by any method acceptable to Engineer which will not impose excessive concentrated or unbalanced loads, shock, or impact on, and will not result in displacement of installed pipe
   3. Until compacted depth over conduit exceeds 3 feet, do not drop fill material over 5 feet. Distance may be increased 2 feet for each additional 1 foot of cover

G. Finish the top portion of backfill with at least 4 inches of topsoil or as specified by landscaping specifications, whichever is greater, corresponding to, or better than, that underlying adjoining turf areas.

H. Trench backfill within the public right-of-way will conform to municipal street and utility standards.

I. Trench backfills through unimproved areas should be restored to previous conditions and left 3” above adjacent grades to allow for settlement. Seed all disturbed areas according to erosion control and landscape specifications.

J. Protection of trench backfill
   1. Where trenches are constructed in ditches or other water courses, protect backfill from erosion
   2. Install ditch checks where the ditch grade exceeds 1 percent
      a. Minimum depth: 2 feet below the original ditch or water course bottom for the full bottom width
      b. Minimum width: 18 inches into the side slopes
      c. Minimum thickness: 12 inches

3.18 DRAINAGE MAINTENANCE

A. Do not backfill trenches across roadways, drives, walks or other trafficways adjacent to drainage ditches or water courses prior to backfilling the trench on the upstream side of the trafficway to prevent impounding water after pipe is laid

B. Backfill so that water does not accumulate in unfilled or partially filled trenches

C. Remove materials deposited in roadway ditches or other water courses crossed by the trench line immediately after backfilling is completed and restore ditches and water courses to original section, grade, and contours

D. Do not obstruct surface drainage any longer than necessary

E. Provide and maintain temporary bridges and other structures across unfilled trenches as required to maintain traffic

F. Provide adequate storm flow conveyance through the site at all times during construction to avoid flooding of any buildings or adjacent property. Provide overland drainage routing when storm sewer inlets are not fully functioning due to erosion and sediment control measures.

3.19 FINAL GRADING

A. After completion of all other outside work and after backfilling is completed and settled, bring to grade at the indicated elevations, slopes and contours, all areas being graded on site
B. Graders and other power equipment may be used for final grading and slope dressing if the result is uniform and equivalent to hand work.

C. Grade all surfaces for effective drainage, provide a 2 percent minimum slope except as otherwise shown on the Drawings.

D. Provide a smooth transition between adjacent existing grades and new grades.

E. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

F. Slope grades to direct water away from buildings and prevent ponds from forming where not intended.

G. Finish subgrades at lawns and unpaved areas to required elevations within a tolerance of plus or minus one (1) inch.

H. Finish grades will be no more than 0.1 foot above or below those indicated.

I. Finish all ditches, swales and gutters to drain readily.

J. Coordinate final subgrade depth with finish landscape treatment and required topsoil depths.

K. Topsoil
   1. Clean topsoil, free of plants and seed will be spread to 4-inch minimum depth, or as specified by landscaping specifications and Drawings, whichever is greater, for areas of the site as detailed by the landscape Drawings.
   2. Reuse grubbings and surface topsoil containing plants and seeds in designated revegetation areas only.

3.20 SLOPE AND CHANNEL STABILIZATION

A. Cover channel banks, slopes, bottom and thalweg (water flowline at lowest point in channel) with erosion control fabric mat where grade is steeper than 4H to 1V and where indicated on the Drawings.

B. Lay fabric smoothly on surface, bury top end of each section in 6-inch deep excavated topsoil trench. Provide 6-inch overlap minimum of adjacent rolls. Backfill trench and rake smooth, level with adjacent soil.

C. Secure outside edges and overlaps at 48 inch intervals with 4-inch to 6-inch U-shaped type pins or wooden stakes depending on ground condition.

D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

F. Maintain integrity of erosion control fabric.

G. Prior to laying fabric, seed disturbed areas under provisions of related seeding and landscaping specification sections.

3.21 SETTLEMENT

A. Warranty for settlement of all fills, embankments, and backfills is stipulated in the General Conditions from final completion of Contract under which Work is performed.

B. Repair or replace within 30 days after notice by Engineer or Owner.

3.22 FIELD QUALITY CONTROL

A. Provide under provisions of General Conditions and Division One Specifications.
B. Coordinate testing with Owner. Owner will provide all field testing to determine compliance of in-place and backfill materials and compaction in accordance with the specifications, and to verify design bearing capacities.

C. It is the Contractor’s responsibility to initiate, coordinate and accommodate all required tests and inspections including conformance with requirements of all applicable public agencies and authorities. Contractor will be responsible for coordinating the testing requirement with testing agency and provide the testing agency contractually required advance notification to schedule tests.

D. Fills and Embankment Testing
   1. Two moisture-density relationship tests, ASTM D698, on each type of fill material
   2. One in-place compaction test for each 5,000 square feet every 1.5 feet of vertical lift of material placed
   3. Additional in-place compaction tests at the discretion of the Owner

E. Pipe Embedment and Backfill Testing
   1. Two moisture-density relationship tests, ASTM D698, or two relative density tests, ASTM D4253/D4254, as appropriate for each type of embedment on backfill material proposed, except granular embedment material
   2. One in-place compaction test every 200 lineal feet of trench in the compacted embedment zone and at every 1.5 feet of vertical lift of backfill materials, per ASTM D6938
   3. One in-place compaction test near top of trench for trench depth of 2 feet or less, per ASTM D6938
   4. Additional in-place compaction tests at the discretion of the Owner

F. Pavement and Structural Subgrade Testing
   1. At a minimum, two moisture-density relationship tests, ASTM D698, or two relative density tests, ASTM D4253/D4254, as appropriate and adequate for each type backfill material proposed.
   2. Perform tests for each footing, concrete site feature, and drainage structure subgrade. Perform tests at every 100 linear feet of subgrade of foundation walls, retaining walls, and every 150 feet for curbing, pans, drainage features, walks, etc. (or portions thereof). Perform tests every 2,000 square feet required of building slab area, exterior slabs and pavement/flatwork areas (with no less than 3 tests). Test at subgrade and at every vertical lift of backfill materials placed.
   3. Additional in-place compaction tests at the discretion of the Owner

G. Inspection and approval
   1. A qualified Geotechnical Engineer will inspect the natural soil at bottom of excavations for structures
   2. Do not prepare subgrade or place concrete until Geotechnical Engineer’s inspection has taken place and any resulting recommendations of the Geotechnical Engineer have been fulfilled or until the inspection has been waived by the Geotechnical Engineer
   3. Prior to placement of structural fill, overexcavated foundations subgrades will be observed and tested by a qualified Geotechnical Engineer to ensure suitable bearing materials exist
   4. Geotechnical Engineer will provide a letter to Engineer to confirm the presence of suitable subgrade material and properly placed fill materials by Contractor in accordance with Drawings and geotechnical report.

H. Retesting of failed compaction will be performed by Geotechnical Engineer for Owner, but paid for the Contractor

END OF SECTION
PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes requirements for stripping sod, and removing and disposing of vegetation and debris.

B. Related Sections:
   1. Division 01 Section “Temporary Facilities and Controls”.
   2. Division 01 Section “Erosion and Sedimentation Control”.
   3. Division 01 Section “Tree Retention and Protection”.
   4. Division 31 Section “Earth Moving”
   5. Division 32 Section “Tree Transplanting”.

1.3 DEFINITIONS

A. The term “sod stripping” shall be used when the vegetative material to be removed is mowable and generally less than twelve-inches (12”) tall.

B. The term “tree removal” refers to individual woody plants with a caliper over four-inches (4”). Any removals shall be performed by a licensed tree Contractor approved by the Town of Erie.

C. The term “clearing” refers to removing and disposing of trees, brush, stumps, logs, grass, weeds, roots, decayed vegetable matter, poles, stubs, rubbish, refuse dumps, sawdust piles, and loose boulders of one cubic yard (1 yd³) or less existing outside of the construction limits, debris resting on or protruding through the ground surface, or appearing on the construction limits before final acceptance of the work. Clearing also includes removing and disposing of obstructions, such as fences, bridges, buildings, and other incidental structures within the construction limits and shown on the Site Demolition Plans.

D. The term “grubbing” refers to removal from the area within the construction limits and proper disposal of all objectionable matter defined above under clearing, which is embedded in the underlying soil. Grubbing also includes removing and properly disposing of sidewalks, driveways, catch basins, drop inlets, manholes, curbing, retaining walls, utilities, foundations, paved floors, underground tanks, and portions of plants to be removed that are below grade, and other structures within the construction limits.

E. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.

F. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow, and; reasonably free of subsoil, clay lumps, gravel, and other objects more than two-inches (2”) in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

G. Plant-Protection Area: Area surrounding shrub beds or massings, or other vegetation or sensitive areas to be protected during construction, and indicated on Contract Drawings.

H. Tree-Protection Area: Area surrounding individual trees or groups of trees to be protected during construction, see Division 01 Section “Tree Retention and Protection”.

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Waggener Farm Park – Phase 1 CLEARING AND GRUBBING 100% Design Development
I. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

A. All materials except for stripped topsoil and those materials indicated to remain or to be stockpiled, shall remain the property of the Town. All other materials shall be removed at the Contractor's expense.

1.5 SUBMITTALS

A. Existing Conditions: Documentation of existing conditions, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   1. Use sufficiently detailed digital photographs or videos.
   2. Include plans and notations to indicate specific damaged conditions of existing construction, site elements, and landscape.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions. Submit to Project Manager prior to start of construction.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Project Manager.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Project Manager.

B. Improvements on Adjoining Property: Not allowed without prior approval from Project Manager. Work only within Work Limit Line as defined on drawings.

C. Salvable Items: Carefully remove items indicated to be salvaged and store on Town property where indicated.

D. Protection and Repair of Underground lines:
   1. Existing Public Utilities: Locate existing underground utilities within the limits of work per General Contract Conditions, Article 804 Protection of Municipal, Public Service or Public Utility Systems. Request utility locates seventy-two (72) hours in advance of any excavations by calling the Utility Notification Center of Colorado at 811. The contractor is responsible for providing written and graphical documentation from the utility owner. Take whatever precautions are necessary including potholing to verify location and depth to protect these underground lines from damage. Should unmarked or incorrectly marked utilities or other piping be encountered during excavation, notify the Project Manager immediately for direction. If damage does occur, all damage shall be repaired by the utility owner and all costs of such repair shall be paid by the contractor. Only written all clears will be acceptable, verbal all clears will not be accepted.
   2. Existing Private Utilities: Locate existing underground utilities within the limits of work per General Contract Conditions, Article 804 Protection of Municipal, Public Service or Public Utility Systems. The contractor is required to contact all private utility companies including the Town of Erie and Weld County to locate all private utilities. The contractor is responsible for providing written and graphical documentation from the private utility owner. The request for locates shall be a minimum of seventy-two (72) prior to proceeding with any excavation. If, after such requests, private utilities are encountered and damaged by the contractor these shall be repaired at no cost to the Town. If the contractor damages staked or located private utilities, they shall be repaired by the utility owner and all costs of such repair shall be paid by the contractor. Only written all clears will be acceptable, verbal all clears will not be accepted.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and tree and or plant protection measures are in place.
PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

1.7 PROTECTION
A. Protect existing site conditions from damage during construction.
   1. Restore existing conditions damaged by Contractor during the work of this Contract to their original condition, as acceptable by Project Manager.

1.8 TRANSPLANTING
A. See Division 32 Section “Tree Transplanting”.

1.9 CLEARING
A. Remove brush and vegetation from areas designated to be cleared. As directed by Project Manager, trim low hanging, unsound, or unsightly branches on existing trees and shrubs designated to remain. All cuts shall be in accordance with Erie Forestry standards.

1.10 GRUBBING
A. Remove all stumps, roots, and debris a minimum of twelve-inches (12") below finish grade in all areas as required. Use hand methods for grubbing inside drip line of trees to remain. Backfill and compact stump and root holes to a maximum of eighty five percent (85%) standard proctor in landscape areas and ninety five percent (95%) standard proctor under hardscape or as directed by the Town Arborist and Project Manager.

1.11 TOPSOIL STRIPPING
A. See Division 31 Section “Earth Moving”.

1.12 SOD STRIPPING
A. Strip sod in all areas to be re-graded to a depth of one-inch (1”), so that a relatively clean dirt surface remains.

1.13 TREE REMOVAL
A. In all proposed landscaped areas, stumps and surface roots shall be ground to a minimum of twelve-inches (12") below finish grade. In proposed hardscape areas, all roots shall be removed entirely.

1.14 DISEASED TREE REMOVAL AND DISPOSAL
A. The removal of diseased and infested trees includes the requirement of offsite burial of all parts of the trees immediately following removal. This includes logs, stumps, roots, branches and composted and un-composted chips. Under no circumstances should diseased or infected wood be left or taken for firewood, mulch or taken to a wood processing mill.

1.15 DISPOSAL
A. Haul and dispose of all removed materials, trash, debris and waste materials legally outside of the Town’s property. All recyclable materials shall be hauled to nearest recycling center and any non-recyclable materials shall be hauled to Denver Arapahoe Disposal Site (DADS). DADS Disposal tickets shall be provided to the Contractor by Project Manager.
PART 1 GENERAL

1.1 SECTION INCLUDES

A. This work consists of temporary measures needed to control erosion and water pollution. These temporary measures will include, but not be limited to, berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains, and other erosion control devices or methods. These temporary measures shall be installed at the locations where needed to control erosion and water pollution during the construction of the project and during site restoration, and as directed by ENGINEER, and as shown on the drawings.

B. The Erosion Control Plan presented in the drawings serves as a minimum for the requirements of erosion control during construction. Contractor has the ultimate responsibility for providing adequate erosion control and water quality throughout the duration of the project. Therefore, if the provided plan is not working sufficiently to protect the project areas, then Contractor shall provide additional measures as required to obtain the required protection.

C. Contractor shall include in the bid price for erosion control a minimum of all items shown on the Erosion Control Plan and any additional items that may be needed to control erosion and water pollution.

1.2 REFERENCES AND STANDARDS

A. CDOT – Colorado Department of Transportation

B. UDFCD – Urban Drainage and Flood Control District

C. CDPHE – Colorado Department of Public Health and Environment

1.3 SUBMITTALS

A. Submit under provisions of Division One specifications.

B. Submit the following information:
   1. Erosion Control Plan,
   2. Construction schedule for Erosion Control per Article Scheduling,
   3. Sequencing Plan per Article Scheduling,
   4. All applicable permits for Erosion Control.

C. Product data: Submit on all products or materials supplied herein.

1.4 REGULATORY REQUIREMENTS

A. Obtain and comply with all requirements of Town of Berthoud and CDPHE Stormwater and/or Groundwater Discharge Permits, as required.

B. 401 Construction Dewatering Industrial Wastewater Permit (Construction Dewatering Permit 401):
   1. Contractor shall apply for and obtain a Construction Dewatering Permit 401 from the Colorado Department of Public Health and Environment.
   2. All costs for this permit shall be the responsibility of Contractor.
   3. This permit requires that specific actions be performed at designated times.
4. Contractor is legally obligated to comply with all terms and conditions of the permit including testing for effluent limitations.

5. Contractor shall allow the Colorado Department of Public Health and Environment or other representatives to enter the site to test for compliance with the permit.

6. Non-compliance with the permit can result in stoppage of all work.

C. In the event of conflict between these requirements and erosion and pollution control laws, rules, or regulations of other Federal, State, or local agencies, the more restrictive laws, rules, or regulations shall apply.

1.5 SCHEDULING

A. Sequencing Plan:
   1. Contractor shall submit a sequencing plan for approval for erosion control in conformance with Contractor’s overall Construction Plan for approval by Town of Berthoud.
   2. Changes to the Erosion Control Sequencing Plan may be considered by Town of Berthoud only if presented in writing by the Contractor.

B. Temporary Erosion Control:
   1. When so indicated in the Contract Documents, or when directed by Town of Berthoud, Contractor shall prepare construction schedules for accomplishing temporary erosion control work including all maintenance procedures.
   2. These schedules shall be applicable to clearing and grubbing, grading, structural work, construction, etc.

C. Contractor shall submit for acceptance the proposed method of erosion control on haul roads and borrow pits and a plan for disposal of waste material.

D. Contractor shall be required to incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in the accepted schedule. Temporary erosion control measures shall then be used to correct conditions that develop during construction.

E. Work shall not be started until the erosion control schedules and methods of operations have been accepted.

PART 2 PRODUCTS

2.1 MATERIALS

A. Comply with all applicable municipal or local Municipal Separate Storm Sewer System (MS4) requirements.

B. All materials shall be submitted for approval prior to installation.

C. Natural or biodegradable materials shall be reasonably clean, free of deleterious materials, and certified weed free. Materials may include, but are not limited to, hay bales, straw, fiber mats, fiber netting, wood cellulose, fiber fabric, gravel.

D. Grass Seed:
   1. Temporary grass cover (if required) shall be a quick growing species, suitable to the area, in accordance with local criteria and permit requirements, which will provide temporary cover, and not compete with the grasses sown for permanent cover.
   2. All grass seed shall be approved by Landscape Architect, Engineer, Town of Berthoud, and the owner and in accordance with local regulations prior to installation.

E. Fertilizer and soil conditioners shall be approved by Landscape Architect, Engineer, Town of Berthoud, Owner and in accordance with local regulations prior to installation.
F. Silt Fence Fabric: woven polypropylene
   1. Mirafi 100X, "Envirofence"
   2. Or accepted substitution

G. Temporary Slope Stabilization Mat (short term): 1.5 pound photodegradable polypropylene top and bottom nets, 100% straw fiber matrix, with a longevity of 12 months.
   1. North American Green S150
   2. Or accepted substitution

H. Temporary Slope Stabilization Mat (extended term): 3.0 pound UV-stable polypropylene top net, 1.5 pound photodegradable polypropylene bottom net, 70% straw/30% coconut fiber matrix with a longevity of 24 months.
   1. North American Green SC150
   2. Or accepted substitution

I. Biodegradable Slope Stabilization Mat (short term): 9.3 pound leno-woven biodegradable jute top net, 7.7 pound woven biodegradable jute bottom net, 100% straw fiber matrix with a longevity of 12 months.
   1. North American Green S150BN
   2. Or accepted substitution

J. Biodegradable Slope Stabilization Mat (extended term): 9.3 pound leno-woven biodegradable jute top net, 7.7 pound woven biodegradable jute bottom net, 70% straw/30% coconut fiber matrix with a longevity of 18 months.
   1. North American Green SC150BN
   2. Or accepted substitution

K. Permanent Channel Stabilization Mat [flow velocities between 9.5 (unvegetated) and 15 (vegetated) fps]:
   5.0 pound UV-stable polypropylene top and bottom nets, 24 pound UV-stable polypropylene corrugated center net, 70% straw/30% coconut fiber matrix.
   1. North American Green SC250
   2. Or accepted substitution

L. Permanent Channel Stabilization Mat [flow velocities between 10.5 (unvegetated) and 20 (vegetated) fps]:
   8.0 pound UV-stable polypropylene top and bottom nets, 24 pound UV-stable polypropylene corrugated center net, 100% coconut fiber matrix.
   1. North American Green SC350
   2. Or accepted substitution

M. Permanent Channel Stabilization Mat [flow velocities between 12.5 (unvegetated) and 25 (vegetated) fps]:
   24 pound UV-stable polypropylene top and bottom nets, 24 pound UV-stable polypropylene corrugated center net, 100% polypropylene fiber matrix.
   1. North American Green P550
   2. Or accepted substitution

PART 3    EXECUTION

3.1 GENERAL

A. All temporary and permanent erosion and sediment control practices will be maintained and repaired as needed to ensure continued performance of their intended function.

B. Town of Berthoud will monitor Contractor’s erosion control methods. If the overall function and intent of erosion control is not being met, Town of Berthoud will require Contractor to provide additional measures as required to obtain the desired results.

C. The erosion control features installed by Contractor shall be adequately maintained by Contractor until the project is accepted.
3.2 PROTECTION OF ADJACENT PROPERTIES

A. Properties adjacent to the site of a land disturbance shall be protected from sediment deposition.

B. In addition to the erosion control measures required on the drawings, perimeter controls may be required if damage to adjacent properties is likely, and may include, but is not limited to:
   1. Vegetated buffer strip around the lower perimeter of the land disturbance.
      a. Vegetated buffer strips may be used only where runoff in sheet flow is expected and should be at least twenty (20) feet in width.
   2. Sediment barriers such as straw bales, erosion logs, and silt fences.
   3. Sediment basins and porous landscape detention ponds.
   4. Combination of above measures.

3.3 CONSTRUCTION

A. Stabilization of Disturbed Areas:
   1. Temporary sediment control measures shall be established within five (5) days from time of exposure or disturbance.
   2. Permanent erosion protection measures shall be established within five (5) days after final grading of areas.

B. Stabilization of Sediment and Erosion Control Measures:
   1. Sediment barriers, perimeter dikes, and other measures intended to either trap sediment or prevent runoff from flowing over disturbed areas shall be constructed as a first step in grading and be made functional before land disturbance takes place.
   2. Earthen structures such as dams, dikes, and diversions shall be stabilized within five (5) days of installation.
   3. Stormwater outlets shall also be stabilized prior to any upstream land disturbing activities.

C. Stabilization of Waterways and Outlets:
   1. All onsite stormwater conveyance channels used by Contractor for temporary erosion control purposes shall be designed and constructed with adequate capacity and protection to prevent erosion during storm and runoff events.
   2. Stabilization adequate to prevent erosion shall also be provided at the outlets of all pipes and channels.

D. Storm Sewer Inlet Protection: All storm sewer inlets which are made operable during construction or which drain stormwater runoff from a construction site shall be protected from sediment deposition by the use of filters.

E. Construction Access Routes:
   1. Wherever construction vehicles enter or leave a construction site, a Stabilized Construction Entrance is required.
   2. Where sediment is transported onto a public road surface, the roads shall be cleaned thoroughly at the end of each day.
   3. Sediment shall be removed from roads by shoveling or sweeping and be transported to a sediment controlled disposal area.
   4. Street washing shall be allowed only after sediment is removed in the manner described above.

3.4 DISPOSITION OF TEMPORARY MEASURES

A. All temporary erosion and sediment control measures shall be disposed of within thirty (30) days after final site stabilization is achieved or after the temporary measures are no longer needed as determined by Town of Berthoud.

B. Trapped sediment and other disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion.
C. Substantial Completion of Erosion Control Measures:
   1. At the time specified in the Contract Documents, and subject to compliance with specified materials
      and installation requirements, Contractor shall receive a Substantial Completion Certificate for
      temporary erosion control measures.
   2. Maintenance of Erosion Control Measures after Substantial Completion: Contractor shall be
      responsible for maintaining temporary erosion control measures as specified in the drawings and
      Contract Documents until such time as work has been accepted by Town of Berthoud and as specified
      in Division 1 for Closeout Procedures.

END OF SECTION
SECTION 31 6329
DRILLED CONCRETE PIERS AND SHAFTS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Machine drilled shafts.
B. Concrete and reinforcement.
C. Shaft liner, if required.

1.02 PRICE AND PAYMENT PROCEDURES
A. See Section 01 2200 - Unit Prices, for additional unit price requirements.
B. Designed Piers:
   1. Design Pier Quantity: Determined by quantity of piers indicated on Drawings.
   2. Design Pier Length: By the linear foot measured from bearing to top of pier elevation as indicated.
   3. Pier Reinforcement: By the linear foot of full pier.
C. Actual Piers:
   1. Actual Pier Quantity: Determined by quantity of piers identified in the Project Record Documents.
   2. Actual Pier Length: Determined by length of piers identified in Project Record Documents.
      a. Base measurement on total linear measurement of piling from bearing to top of pier, except for test piers calculated at 5 feet longer.
D. Adjustments to the Contract Sum/Price will be made if the Actual Pier Quantity or Length differs from Design Pier Quantity or Length, based on unit prices established in the Agreement and as follows:
   1. Actual Pier Quantity.
   2. Actual Pier Length.
   3. Unit price per unit length. To calculate cost adjustment, multiply unit price by difference between Design Pier Length and Actual Pier Length.
E. Determination of Unit Measurements: Identified by site measurements and verified by independent testing and inspection agency.
   1. Variations in actual pier lengths will be based solely on the testing agency reports, and Contract Sum will be adjusted according to unit prices stated in the Agreement.
   2. Payment will not be made for over runs not indicated in the testing agency reports, nor for casings used for convenience and not required to control water or sloughing of excavations, nor for additional concrete needed to fill difference between design diameters and actual pier diameters.

1.03 REFERENCE STANDARDS

1.04 ADMINISTRATIVE REQUIREMENTS
A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this Section.
   1. Convene under general provisions of Section 01 7000.
   2. Require attendance by all affected installers.

1.05 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Project Record Documents: Record actual locations of piers, pier diameter, and pier length. Accurately record the following:
   1. Sizes, lengths, and locations of piers.
   2. Sequence of placement.
   3. Final base and top elevations.
   4. Deviation from indicated locations.
   5. Placement and configuration of reinforcement deviations.

1.06 QUALITY ASSURANCE
   A. Installer Qualifications: Company specializing in performing the work of this Section with minimum 3 years of documented experience.

PART 2 PRODUCTS
2.01 MATERIALS
   A. Casing: Temporary casings of steel complying with ASTM A283/A283M, Grade C; ASTM A36/A36M; or ASTM A929/A929M; of sufficient strength to withstand handling and drilling stresses, concrete pressures, and surrounding earth and water pressures.
   B. Concrete Materials and Mix: Specified in Section 03 3000.
   C. Reinforcement: Specified in Section 03 3000.
   D. Equipment: Appropriate for dewatering excavated shaft.

PART 3 EXECUTION
3.01 PREPARATION
   A. Use placement method which will not cause damage to nearby structures.
   B. Notify adjacent and affected land owners and building occupants with 90 days notice before proceeding with the work.
   C. Protect structures near the work from damage.
   D. Prepare to place piers from excavated working elevations.
   E. Grade perimeter of pier and shaft area to prevent surface water from draining into soil borings. Provide temporary means and methods, as required, to maintain surface diversion until no longer needed, or as directed by the Architect.

3.02 INSTALLATION
   A. Construct piers in accordance with ACI 336.1.
   B. Drill vertical pier shafts to diameters and depths indicated on Drawings.
   C. Place steel casings immediately after drilling. Set firmly in place. If casing is to be temporary, install with sufficient strength to withstand concrete pressures.
   D. Clean shaft and bottom of loose material. Provide temporary means and methods, as required, to remove and maintain all water from open shaft borings as needed, or until directed by Owner's geotechnical engineering consultant.
   E. Allow inspection of shafts prior to placement of reinforcement and concrete.
   F. Place reinforcing steel in accordance with Section 03 3000.
   G. Place concrete in single, continuous pour for each pier, in accordance with Section 03 3000, with equipment designed for vertical placement of concrete so that concrete is positively conveyed to the location of placement, and discharged from placement equipment within 10 feet of the level of placement.
      1. Vibrate minimum top 5 feet of each pier.
2. Free fall placement methods may be used provided concrete is directed such that the fall is vertical down the center of the shaft without contacting sides of excavation or reinforcing.

H. Coordinate casing withdrawal with concrete placement so that concrete pressure head exceeds anticipated outside soil and water pressure above bottom of casing at all times during withdrawal.

I. Extend reinforcement for connection of pier caps and grade beams.

J. Set tops of piers to elevations indicated.

K. Design of piers is based on assumed soil strata bearing capacity determined by Owner's geotechnical engineering consultant. If bearing strata is not capable of maintaining assumed bearing capacity, as determined by observation or testing by testing agency or Owner's geotechnical engineering consultant, design will modified by Architect; cost of modifications will be subject to specified modification procedures.

3.03 TOLERANCES

A. Install piers with maximum variation from location, plumbness, bottom area, diameter, and anchorage locations as specified in ACI 336.1, except as follows:
   1. Maximum Variation From Vertical: 1 percent of vertical pier length.
   2. Maximum Variation From Design Top Elevation: Plus 3 inches, minus 1 inch.
   3. Maximum Out-of-Position: The lesser of 10 percent of pier diameter or 3 inches.

3.04 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 01 4000 - Quality Requirements.

B. Testing agency will:
   1. Inspect drilling, determine suitability of bearing soils, inspect reinforcing, and approve such conditions as meeting the requirements of the Contract Documents prior to pouring each pier.
   2. Log top and bottom of each pier shaft to determine depth required to reach satisfactory bearing.
   3. Submit daily reports containing shaft identification, diameter, design and actual bottom elevations, top elevation, tolerance deviations, amount of over run or under run, bearing surface description and condition, water conditions during drilling and at time of concrete placement, and unusual conditions observed.

C. Perform concrete tests to requirements of Section 03 3000.

3.05 UNACCEPTABLE PIERS

A. Unacceptable Piers: Piers that fail, are placed out of position, are below elevations, or are damaged.

B. Provide additional piers or replace piers failing to comply with specified requirements.

END OF SECTION
PART 1 GENERAL

A. The work of this section consists of all Structural Soil work and related items as indicated on the drawings or as specified herein and includes, but is not limited to, the following:

CU-Structural Soil® or approved equal. For a list of licensed CU-Soil™ producers, call AMEREQ, INC. at 800-832-8788.

1.2 REFERENCES AND STANDARDS

A. The following references are used herein and shall mean:

1. ASTM: American Society of Testing Materials
2. USDA: United States Department of Agriculture
3. AASHTO: American Association of State Highway and Transportation Officials
4. Standard Specifications: Regional or Municipal Standard Specifications Documentation for the location of proposed usage
5. AOAC: Association of Official Agricultural Chemists

1.3 SAMPLES AND SUBMITTALS

A. At least 30 days prior to ordering materials, the installing contractor shall submit to the engineer representative samples, certificates, manufacturer’s literature and test results for materials specified below. No materials shall be ordered until the required samples, certificates, manufacturer’s literature, producer’s current license and test results have been reviewed and approved by the landscape architect and/or engineer. The engineer reserves the right to reject any material that does not meet CU-Structural Soil® specifications. Delivered materials shall closely match the approved samples.

B. Submit from licensed producer, 1/2 cubic foot representative sample of clay loam, one cubic foot representative sample of crushed stone, and one cubic foot representative sample of CU-Structural Soil® mix for approval. In the event of multiple source fields for clay loam, submit a minimum of one set of samples per source field or stockpile. The samples of all clay loam, crushed stone, and CU-Structural Soil® shall be submitted to the engineer as a record of the soil color and texture.

C. Submit soil test analysis reports for sample of clay loam from an independent soil-testing laboratory. The testing laboratory for particle size and chemical analysis may include a public agricultural extension service agency.

1. Submit a mechanical analysis of the clay loam sample and particle size analysis including the following gradient of mineral content:
   USDA Designation Size in mm.
   - Gravel +2 mm
   - Sand 0.05 – 2 mm
   - Silt 0.002-0.05 mm
   - Clay minus 0.002 mm

2. Sieve analysis shall be performed and compared to USDA Soil Classification System.

3. Sieve analysis shall be done by a combined hydrometer and wet sieving using sodium hexametaphosphate as a dispersant in compliance with ASTM D422 after destruction of organic matter by hydrogen peroxide.

4. Submit a chemical analysis, performed in accordance with current AOAC Standards, including the following:
   a. pH and buffer pH.
b. Percent organic matter as determined by the loss of ignition of oven dried samples. Test samples shall be oven dried to a constant weight at a temperature of 230 degrees F, plus or minus 9 degrees.

c. Analysis for nutrient levels by parts per million.

d. Soluble salt by electrical conductivity of a 1:2 soil/water sample measured in Millimho per cm.

e. Cation Exchange Capacity (CEC).

f. Carbon/Nitrogen Ratio.

D. Submit one cubic foot sample of crushed stone which will be used in production of CU-Soil™.

1. Provide particle size analysis:

   USDA Designation Size in mm.
   3" +76 mm
   21/2" 63-76 mm
   2" 50-63 mm
   11/2" 37-50 mm
   1" 25-37 mm
   ¾" 19-25 mm
   Fine gravel 2-19 mm

2. Provide the manufacturer’s analysis of the loose and rodded unit weight

3. Losses from LA Abrasion tests- not to exceed 40%

4. Minimum 90% with 2 or more fractured faces

5. Percent pore space analysis

E. At the engineer’s discretion, the sample of CU-Structural Soil® may be tested for the following:

1. Compaction in accordance with ASTM D698/AASHTO T99 without removing oversize aggregate

2. California Bearing Ratio in accordance with ASTM D1883- soaked CBR shall equal or exceed a value of 50

3. Measured dry-weight percentage of stone in the mixture

F. The approved CU-Structural Soil® sample shall be the standard.

G. Any deviation from the specified crushed stone and clay loam specifications shall be approved by Amereq, Inc.

1.4 DELIVERY, STORAGE AND HANDLING

A. Delivered CU-Structural Soil® shall be at or near optimum compaction moisture content as determined by AASHTO T 99 (ASTM D 698) and should not be placed in frozen, wet or muddy sites.

B. Protect CU-Structural Soil® from exposure to excess water and from erosion at all times. Do not store CU-Soil™ unprotected. Do not allow excess water to enter site prior to compaction. If water is introduced into the CU-Soil™ after grading, allow water to drain to optimum compaction moisture content.

1.5 EXAMINATION OF CONDITIONS
A. All areas to receive CU-Structural Soil® shall be inspected by the installing contractor before starting work and all defects such as incorrect grading, compaction, and inadequate drainage shall be reported to the engineer prior to beginning this work.

1.6 QUALITY ASSURANCE

A. Qualifications of installing contractor: The work of this section should be performed by a contracting firm which has a minimum of five years experience. Proof of this experience shall be submitted as per paragraph, SAMPLES and SUBMITTALS, of this section.

PART 2 PRODUCTS

2.1 CLAY LOAM

A. Soil shall be a “loam” with a minimum clay content of 20% or a “clay loam” based on the “USDA classification system” as determined by mechanical analysis (ASTM D-422) and it shall be of uniform composition, without admixture of subsoil. It shall be free of stones, lumps, plants and their roots, debris and other extraneous matter. It shall not contain toxic substances harmful to plant growth. Clay loam shall contain not less than 2% or more than 5% organic matter as determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F., plus or minus 9 degrees.

B. Mechanical analysis for the loam or clay loam shall be as follows:

<table>
<thead>
<tr>
<th>Textural Class % of Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel less than 5%</td>
</tr>
<tr>
<td>Sand 20-45%</td>
</tr>
<tr>
<td>Silt 20-50%</td>
</tr>
<tr>
<td>Clay 20-40%</td>
</tr>
</tbody>
</table>

C. Chemical analysis: Meet, or be amended to meet the following criteria:

1. pH between 5.5 to 6.5
2. Percent organic matter 2% - 5% by dry weight
3. Adequate nutrient levels
4. Soluble salt less than 1.0 mmho/cm
5. Cation Exchange Capacity (CEC) greater than 10
6. Carbon/Nitrogen ratio less than 33:1

D. Loam or clay loam shall not come from USDA - classified prime farmland.

2.2 FERTILIZER (if needed)

A. Should nutrient analysis suggest that the loam or clay loam need additional nutrients, it shall be amended by Amereq’s licensed producer.

2.3 SULFUR (if needed)

A. Sulfur shall be a commercial granular, 96% pure sulfur, with material and analysis appearing on the labeled container.

B. Sulfur used to lower pH shall be a ferrous sulfate formulation.

C. Application rates shall be dependent on soil test results.

2.4 LIME (if needed)

A. Agricultural lime containing a minimum of 85% carbonates.
B. Application rates shall be dependent on soil test results.

2.5 CRUSHED STONE

A. The size of the crushed stone shall be 0.75 inches to 1.5 inches allowing for up to 10% being greater than 1.5 inches, and up to 10% less than 0.75 inches.

B. Acceptable aggregate dimensions will not exceed 2.5:1.0 for any two dimensions.

C. Minimum 90% with two or more fractured faces.

D. Results of Aggregate Soundness Loss test shall not exceed 18%.

E. Losses from LA Abrasion tests shall not exceed 40%.

2.6 HYDROGEL

A. Hydrogel shall be a coated potassium propenoate-propenamide copolymer (Gelscape® Hydrogel Tackifier) as manufactured by Amereq, Inc. 800-832-8788.

2.7 WATER

A. The installing contractor shall be responsible to furnish his own supply of water (if needed) free of impurities, to the site.

2.8 CU-STRUCTURAL SOIL®

A. A uniformly blended urban tree mixture of crushed stone, clay loam and Gelscape® Hydrogel Tackifier, as produced by an Amereq-licensed company, mixed in the following proportion:

<table>
<thead>
<tr>
<th>Material Unit of Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>specified crushed Stone 100 units dry weight</td>
</tr>
<tr>
<td>specified clay loam 20 – 25 units (to achieve minimum CBR of 50)</td>
</tr>
<tr>
<td>Gelscape® Hydrogel Tackifier 0.035 units dry weight</td>
</tr>
<tr>
<td>moisture ASTM D698/AASHTO T-99 optimum moisture</td>
</tr>
</tbody>
</table>

PART 3 EXECUTION

3.1 CU-SOIL™ MIXING AND QUALITY CONTROL TESTING

A. All CU-Structural Soil® mixing shall be performed at the licensed producer’s yard using appropriate soil measuring, mixing and shredding equipment of sufficient capacity and capability to assure proper quality control and consistent mix ratios. No mixing of CU-Structural Soil® at the project site shall be permitted.

Maintain adequate moisture content during the mixing process. Soils and mix components shall easily shred and break down without clumping. Soil clods shall easily break down into a fine crumbly texture. Soils shall not be overly wet or dry. The licensed producer shall measure and monitor the amount of soil moisture at the mixing site periodically during the mixing process.

B. Raw materials shall be mixed off-site, only at the licensed producer’s facility, on a flat asphalt or concrete paved surface to avoid soil contamination.

C. Should the independent laboratory test results of the clay loam reveal a need to amend it, to meet specifications, the amending materials should be added to the clay loam following the rates and recommendations provided by Amereq.

3.2 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS
A. The installing contractor shall notify the engineer of any subsurface conditions which will affect the contractor’s ability to install the CU-Soil™.

B. The installing contractor shall locate and confirm the location of all underground utility lines and structures prior to the start of any excavation.

C. The installing contractor shall repair any underground utilities or foundations damaged during the progress of this work.

3.3 SITE PREPARATION

A. Do not proceed with the installation of the CU-Structural Soil® material until all walls, curb footings and utility work in the area have been installed. For site elements dependent on CU-Structural Soil® for foundation support, postpone installation of such elements until immediately after the installation of CU-Structural Soil®.

B. Install subsurface drain lines as shown on the plan drawings prior to installation of CU-Structural Soil® material.

C. Excavate and compact the proposed subgrade to depths, slopes and widths as shown on the drawings. Maintain all required angles of repose of the adjacent materials as shown on the drawings. Do not over excavate compacted subgrades of adjacent pavement or structures.

D. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope parallel to the finished grade and/or toward the subsurface drain lines as shown on the drawings.

E. Clear the excavation of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout silts or other material harmful to plants have been spilled into the subgrade material, excavate the soil sufficiently to remove the harmful material. Fill any over excavation with approved fill and compact to the required subgrade compaction.

F. Do not proceed with the installation of CU-Structural Soil® until all utility work in the area has been installed. All subsurface drainage systems shall be operational prior to installation of CU-Structural Soil®.

G. Protect adjacent walls, walks and utilities from damage. Use ½” plywood and/or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work.

1. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each working day.

2. Any damage to the paving or architectural work caused by the installing contractor shall be repaired, as directed by the engineer.

H. Maintain all silt and sediment control devices required by applicable regulations. Provide adequate methods to assure that trucks and other equipment do not track soil from the site onto adjacent property and the public right of way.

3.4 INSTALLATION OF CU-STRUCTURAL SOIL® MATERIAL

A. Install CU-Structural Soil® in 6 inch lifts and compact each lift.

B. Compact all materials to at least 95% Proctor Density from a standard compaction curve AASHTO T 99 (ASTM D 698). No compaction shall occur when moisture content exceeds maximum as listed herein. Delay compaction if moisture content exceeds maximum allowable and protect CU-Structural Soil® during delays in compaction with plastic or plywood as directed by the engineer.

C. Bring CU-Structural Soil® to finished grades as shown on the drawings. Immediately protect the CU-Structural Soil® from contamination by toxic materials, trash, debris, water containing cement, clay, silt or
materials that will alter the particle size distribution of the mix with plastic or plywood as directed by the engineer.

D. The engineer may periodically check the material being delivered, prior to installation for color and texture consistency with the approved sample provided by the installing contractor as part of the submittal for CU-Structural Soil®. If the engineer determines that the delivered CU-Soil™ varies significantly from the approved samples, the engineer shall contact the licensed producer.

E. Engineer shall ensure that the delivered structural soil was produced by the approved CU-Soil™ licensee by inspecting weight tickets showing source of material.

F. CU-Soil™ should not be stockpiled long-term. Any CU-Soil™ not installed immediately should be protected by a tarp or other waterproof covering.

3.5 FINE GRADING

A. After the initial placement and rough grading of the CU-Structural Soil® but prior to the start of fine grading, the installing contractor shall request review of the rough grading by the engineer. The installing contractor shall set sufficient grade stakes for checking the finished grades.

B. Adjust the finish grades to meet field conditions as directed.

1. Provide smooth transitions between slopes of different gradients and direction.

2. Fill all dips with CU-Soil™ and remove any bumps in the overall plane of the slope.

3. The tolerance for dips and bumps in CU-Structural Soil® areas shall be a 3” deviation from the plane in 10’.

4. All fine grading shall be inspected and approved by the engineer prior to the installation of other items to be placed on the CU-Structural Soil®.

C. The engineer will inspect the work upon the request of the installing contractor. Request for inspection shall be received by the engineer at least 10 days before the anticipated date of inspection.

3.6 ACCEPTANCE STANDARDS

A. The engineer will inspect the work upon the request of the installing contractor. Request for inspection shall be received by the engineer at least 10 days before the anticipated date of inspection.

3.7 CLEAN-UP

A. Upon completion of the CU-Structural Soil® installation operations, clean areas within the contract limits. Remove all excess fills, soils and mix stockpiles and legally dispose of all waste materials, trash and debris. Remove all tools and equipment and provide a clean, clear site. Sweep, do not wash, all paving and other exposed surfaces of dirt and mud until the paving has been installed over the CU-Structural Soil® material. Do no washing until finished materials covering CU-Structural Soil® material are in place.

END OF SECTION
PART 1    GENERAL

1.1    SECTION INCLUDES

A. Full depth hot bituminous pavement (asphalt) over prepared subgrade

1.2    REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. T 230: Standard Method of Test of Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures

B. American Society for Testing and Materials (ASTM):
   1. C29: Unit Weight and Voids in Aggregate
   2. C88: Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
   3. C117: Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
   4. C128: Specific Gravity Test and Absorption of Fine Aggregate
   5. C131: Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
   6. C136: Sieve or Screen Analysis of Fine and Coarse Aggregates
   7. D70: Specific Gravity of Semi-Solid Bituminous Materials
   8. D2726: Bulk Specific Gravity of Compacted Bituminous Mixtures
   9. D2041: Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures
  10. D4462: Viscosity of Asphalts (Bitumens)
  11. 2172: Quantities Extraction of Bitumens from Bituminous Paving Mixtures
  12. D2419: Sand Equivalent Value of Soils and Fine Aggregate
  13. D290: Bituminous Mixing Plant Inspection
  14. D6373: Performance Graded Asphalt Binder
  15. D692: Course Aggregate for Bituminous Paving
  16. D1073: Fine Aggregate for Bituminous Paving Mixtures
  17. D1241: Materials for Soil-Aggregate Subbase, Base and Surface Courses
  18. D2026: Cutback Asphalt (Slow-Curing Type)
  19. D2027: Cutback Asphalt (Medium-Curing Type)
  20. D2028: Cutback Asphalt (Rapid-Curing Type)
  21. D2950: Density of Bituminous Concrete in Place by Nuclear Methods

C. Surface Preparation Standards (SSPC)
  1. SP-2: Superior Performing Asphalt Pavement System (Superpave) Level 1 Mix Design

D. Colorado Department of Transportation

E. Colorado Asphalt Pavement Association

F. Town of Berthoud construction specifications, standards and details.

1.3    SUBMITTALS

A. Submit under provisions of Division One Specifications

B. Record of Work: Maintain record of time and date of placement, temperature, and weather conditions, retain until completion and furnish copy to engineer.
C. Proposed Design Job Mix Formula for each mixture required by the contract. The mixture design shall be determined using AASHTO T-312 or Colorado Procedure CP-L 5115 for the Superpave Method of Mixture Design.

D. Test Reports: Proposed Design Job Mix testing shall be performed in a materials laboratory under the direct supervision of; and shall be stamped and signed by a Professional Engineer licensed in the State of Colorado practicing in this field. In addition, the General Contractor shall submit as part of the Proposed Design Job Mix, documents to verify the following:
   1. Source of materials
   2. Gradation, specific gravity, source and description of individual aggregates and the final blend
   3. Aggregate physical properties
   4. Source and Grade of the Performance Graded Binder (PG Binder)
   5. Proposed Design Job Mix – aggregate and additive blending, final gradation shown on 0.45 power graph, optimum asphalt content
   6. Required mixing and compaction temperatures
   7. Mixture properties determined at a minimum of four asphalt contents and interpolated at optimum and graphs showing mixture properties versus asphalt content.
   8. Sampling and testing of asphalt concrete mixtures for quality control during paving operations
      a. Uncompacted asphalt concrete mix
         i) Asphalt cement content: ASTM D2172 (AASHTO T164)
         ii) Maximum Specific Gravity: ASTM D2041 (AASHTO T209)
      b. Compacted asphalt concrete mix
         i) Bulk density: ASTM D1188 (AASHTO T166)
      c. Perform at least one test for each day's paving but not less than one test per each 4000 sf of each lift.

1.4 QUALITY ASSURANCE
   A. Materials and installation shall conform to applicable portions of Colorado Department of Transportation (CDOT) and Town of Berthoud construction specifications, standards and details.

1.5 REGULATORY REQUIREMENTS
   A. For work on public streets or rights-of-way conform to the requirements of Town of Berthoud construction specifications, standards and details for the construction of concrete, curbs, gutters, sidewalks, driveways, roadways, street paving, and other public right-of-way Improvements.
   B. Comply with applicable requirements of CABO/ANSI A117.1 for accessibility requirements related to walks, ramps, parking areas, drives, curb ramps, etc.

1.6 DELIVERY, STORAGE AND HANDLING
   A. Deliver, store, protect and handle materials under provisions of Division One Specifications
   B. Transport mixture from mix plant in trucks with tight, clean, smooth, non-sticking compartments. Thinly coat hauling compartments with lime-water mixture, paraffin oil or other approved release agent to prevent sticking. Petroleum distillates such as kerosene or fuel oil are not approved release agents. Elevate and drain compartment of excess solution before loading mix.
   C. Cover to protect from weather and prevent loss of heat
   D. Provide insulated truck beds during temperature below 50 degrees F on long distance deliveries

1.7 ENVIRONMENTAL REQUIREMENTS
   A. Do not apply when underlying surface is muddy, frozen or wet
B. Weather conditions permit pavement to be properly placed and compacted

C. The hot mix asphalt will be placed only when both the air and surface temperatures are equal to or exceed the temperatures specified in the table below:

<table>
<thead>
<tr>
<th>Compacted Layer Thickness (Inches)</th>
<th>Minimum Air and Surface Temp. (Degrees F and rising)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Layer</td>
<td>Other Layers</td>
</tr>
<tr>
<td>1½ or less</td>
<td>60</td>
</tr>
<tr>
<td>&gt;1½ to 3</td>
<td>50</td>
</tr>
<tr>
<td>3 to 4</td>
<td>45</td>
</tr>
</tbody>
</table>

Air temperature shall be taken in the shade. Surface is defined as the existing base on which the new pavement is to be placed.

PART 2 PRODUCTS

2.1 MATERIALS

A. General: Pavement shall be asphalt of the plant hot mix type. Materials and construction shall comply with Section 403 and 702 of the CDOT Standards and Specifications for Road and Bridge Construction.

B. Tack Coat:
   1. SS-1 or CSS-1h
   2. AASHTO M208 or M140

C. Asphaltic Cement:
   1. Superpave Performance Graded (PG) binder of PG58-28 Table 702-1 of CDOT standard section 702
   2. Will not be acidic modified or alkaline modified
   3. Will not contain any used oils that have not been refined
   4. Modifiers will not be carcinogenic

D. Aggregate for Asphaltic Concrete, General
   1. Sound, angular crushed stone, crushed gravel, or crushed slag: ASTM D692
   2. Sand, stone, or slag screening: ASTM D1073
   3. Percent wear: ASTM C131, less than 45 for aggregates retained in #10 sieve

E. Base Course Aggregates for Asphaltic Concrete
   1. Uncrushed gravel may be used in mixture if it meets design criteria specified
   2. Provide uniform quality combined aggregates with a minimum sand equivalent value of 40
   3. Provide aggregate in gradations for courses to comply with Class S and SG, Colorado Department of Transportation, ASTM C136
   4. A maximum of 20% Reclaimed Asphalt Pavement (RAP) will be allowed in (non-polymer or non-rubberized) mixes, provided that all the requirements for hot bituminous pavement are met.
      a. RAP shall not be allowed in polymer modified mixes or in the permanent final lift of asphalt.

F. Surface Course Aggregates for Asphaltic Concrete
   1. Provide natural sand, unless sand prepared from stone, slag, or gravel or combinations are required to suit local conditions
   2. Provide uniform quality combined aggregate with a minimum sand equivalent value of 50
   3. Provide aggregate in gradations for courses to comply with Class SX, Colorado Department of Transportation, ASTM C136.

G. Hydrated Lime for Aggregate:
1. May be added at the rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve. Hydrated lime for aggregate pretreatment will conform to ASTM C207, Type N. Residue retained on a No. 200 sieve will not exceed 10% when determined in accordance with ASTM C110. Drying of the residue in an atmosphere free from carbon dioxide will not be required.

H. Weed Control: First application, “Roundup.” Second application, Casoron “W-50” or “G-10” with colored marker dye, manufactured by Pacific Coast Borax Company or an accepted substitute of non-flammable type.

2.2 ACCESSORIES

A. Traffic Control Devices
1. Signs.  
   a. Comply with Town of Berthoud standards and specifications for signs within the public right-of-way.  
   b. Sign faces, posts and bases shall be in conformance with the following materials specifications. All nonstandard sign faces, posts and bases must be approved by Town of Berthoud. Private property or nonstandard signs will be maintained by the owner. Submit shop drawings for approval prior to fabrication. All signs shall conform to current M.U.T.C.D. Standards and Colorado Supplements. All signs shall be 3M-engineer grade reflective sheeting or accepted substitute.  
   c. Traffic/Parking Signs: Sign blanks shall be 6061 or 5052-H38 aluminum alloy .080 inches thick. Facing shall be specified reflective sheeting with standard sign colors based on standard graphics and as shown on the plans.

2. Sign Posts.  
   a. For large signs greater than 12"W x 18"H and for multiple signs of any size mounted on the same post: sign posts shall be two (2) inch by two (2) inch galvanized telespar tube.  
   b. For regular single signs 12"W x 18"H or smaller: sign posts shall be one and one-half (1-1/2) inch by one and one-half (1-1/2) inch galvanized telespar tube.  
   c. Galvanized telespar tube shall have 0.120-inch wall thickness, and three-eighths (3/8) inch holes drilled on one (1) inch centers, all sides over full length, ten (10) feet in length (min).

3. Sign Post Anchor Bases (Stubs). All sign post anchor bases shall be twist resistant square galvanized telespar tube post with thickness and hole pattern the same as sign posts. Use 2-1/4" by 2-1/4" anchor for large posts and 1-3/4" by 1-3/4" anchor for regular posts. Bases shall be embedded a minimum of 36" below finished grade and shall extend 3” above finished grade.

4. Signs Post Anchor Bases with concrete footing: Sign, post, base and compacted soil shall be rigid and able to withstand wind loads. Where predominantly clay soils are present which will not properly compact at sign base, install a 6” diameter by 36” deep concrete footing around signs post anchor base for all signs in landscaped areas.

5. All signs and posts shall be mounted and secured with municipal-approved vandal-proof type TL-3896 drive rivets with washers, or accepted substitute.

B. Pavement Marking. Specified pavement marking materials shall be used at locations as identified below.
1. Comply with Town of Berthoud standards and specifications for pavement marking within the public right-of-way.
2. FS TT-P-1952, Type I Alkyd, white, blue, yellow and red color paint meeting requirements of CDOT Standard Specification 708. Verify colors and extent of painting prior to painting. Unless noted on plans, evident at existing striping or instructed, provide white in color for traffic striping, parking stalls, and other control markings on internal pavement, yellow in color for traffic control markings or restricted parking or where indicated, blue in color for accessible parking stalls, and red in color for curbs where no parking is indicated. ReflectORIZED paint required for traffic stripes and control markings on internal drive, road or street pavements.

3. Furnish paint with a no-pick-up maximum drying time of 20 minutes, when tested according to ASTM D711 using a wet film thickness of 0.015-inch when tested and applied at 77 degrees F.

4. 3M Stamark 5730 preformed plastic marking material or an accepted substitute shall be used for crosswalks, stop bars, symbols (i.e. turn arrows) and striping for separation of turn and through lanes in right-of-way. Use of thermoplastic pavement marking is not permitted.
2.3 MIXES/SOURCE QUALITY CONTROL

A. Determine full depth design mix based upon aggregates furnished
   1. Test mix by independent laboratory at Contractor's expense
   2. Grade dependent on temperature during placement
   3. Submit mix designs under provisions of Division One specifications for review and acceptance by Engineer

B. Submit mix design giving unit weight and to meet following requirements prior to placement of asphalt:

<table>
<thead>
<tr>
<th>Property</th>
<th>S(75)</th>
<th>SX(75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Voids in Mix, %</td>
<td>3.5-4.5</td>
<td>3.5-4.5</td>
</tr>
<tr>
<td>(N Design)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Initial Gyrations</td>
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<td>75</td>
</tr>
<tr>
<td>Design Gyrations</td>
<td>28 min</td>
<td>28 min</td>
</tr>
<tr>
<td>Hveem Stability</td>
<td>65-80</td>
<td>65-80</td>
</tr>
<tr>
<td>Voids Filled w/ Asphalt</td>
<td>± 6%</td>
<td>± 6%</td>
</tr>
</tbody>
</table>

Establish a single percentage passing each sieve size, a single percent of asphalt and a mix temperature. Maintain job mixes within following percentages of design mix:

Aggregates:
- %4" and larger ± 6%
- #4 to #8 ± 4%
- #200 ± 2%

Asphalt Content Tolerance ± 0.3%
Discharge Mix temp ± 20˚F

PART 3 EXECUTION

3.1 EXAMINATION

A. Establish and maintain required lines and elevations. Provide grade and location stakes under this section as required for asphaltic concrete paving work.

B. Operate heavy, rubber-tired front loader over subgrade of paved areas. Where soft spots occur, remove loose materials and replace with Class 6 road base aggregate complying with CDOT standards compacted to level of subgrade.

3.2 PREPARATION

A. Prepare subgrade under provisions of Section 31 00 00

B. Loose and Foreign Material
   1. Remove loose and foreign material from compacted subgrade surface immediately before application of paving. Clean surface with mechanical sweeper, blowers, or hand brooms, until surfaces are free from dust.

C. Weed Control
   1. If weeds or vegetation exist at or on the subgrade, apply "Round-up" at rates following manufacturer's instructions. Apply "Round-up" three days prior to removal of vegetation, subgrade preparation and application of Casoron as described below to allow "Round-up" to kill all vegetation. Remove all living and dead weeds, root balls, tree/shrub roots, vegetation, and/or any organic matter from on or in the
subgrade per applicable earthwork specifications prior to subgrade preparation and paving at all areas to be paved.

2. After all fine grading, checking, shaping, and compacting of the subgrade has been completed, and just prior to placing asphalt or aggregate base course, all subgrade soil in the area to receive asphalt pavement shall be thoroughly treated with Casoron soil sterilant (in addition to “Round-up” and regardless of presence of existing weeds or vegetation). Casoron shall be thoroughly sprinkled to distribute the chemical through the first two or three inches of the subgrade. For all areas to be paved, apply Casoron weed control at a minimum rate per 100 square yards of 2.4 pounds for G-10 or 4.0 pounds for 50w at rates and methods recommended by manufacturer within one day of paving.

3. The Contractor shall provide all necessary protection to prevent injury to animal, fish, or plant life and property occasioned by the application of the soil sterilant. Apply on a calm, wind-free day. The Contractor will be held responsible for all application of soil sterilant or the storage of same. Protect existing and new trees and shrubs beyond the limit of paving from damage due to weed killer or soil sterilant overspray or root contact. Extra caution is required to prevent over-application of products in areas to be paved under tree canopies. Trees and shrubs damaged or killed by weed killer or sterilant application shall be replaced by the contractor at contractor’s expense.

4. Do not apply within 20 feet of trees or shrubs

D. Tack Coat
1. Apply in similar manner as prime coat, except as modified
2. Dilute material with equal parts of water and apply to contact surfaces of previously constructed asphaltic concrete or portland cement concrete and surfaces
3. Apply at rate of 0.05 to 0.15 gallons per square yard of surface
4. Apply tack coat by brush to contact surfaces of curbs, gutters, catch basins, and other structures projecting into or abutting asphaltic concrete pavement
5. Allow surfaces to dry until material is at condition of tackiness to receive pavement
6. Where asphaltic concrete will adhere to surface, tack coat may be eliminated by Engineer

3.3 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
1. Mill to minimum depth of 1 ½-inches, or as indicated on the plans.
2. Mill to a uniform finished surface free of gouges, grooves, and ridges of more than ¼ inch depth.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Transport milled hot-mix asphalt to asphalt recycling facility.
7. Keep milled pavement surface free of loose material and dust.

3.4 RING/FRAME ADJUSTMENTS

A. Set ring/frames of subsurface structures to final grade as a part of this work.

B. Placing Ring/Frames
1. Surround ring/frames set to elevation with a ring of compacted asphalt concrete base prior to paving
2. Place asphalt concrete mixture up to 1-inch below top of ring/frame, slope to grade, and compact by hand tamping

C. Adjust frames to proper position to meet paving

D. If permanent covers are not in place, provide temporary covers over openings until completion of rolling operations

E. Set ring/frames to grade, flush with surface of adjacent pavement
3.5 PREPARING THE MIXTURE

A. Comply with ASTM D995 for material storage, control, and mixing and for plant equipment and operation.

B. Stockpile
   1. Keep each component of the various sized combined aggregates in separate stockpiles.
   2. Maintain stockpiles so that separate aggregate sizes will not be intermixed and to prevent segregation.

C. Heating
   1. Heat the asphalt cement at the mixing plant to viscosity at which it can be uniformly distributed throughout mixture.
   2. Use lowest possible temperature to suit temperature viscosity characteristics of asphalt.
   3. Do not exceed 350 degrees F.

D. Aggregate
   1. Heat-dry aggregates to acceptable moisture content.
   2. Deliver to mixer at recommended temperature to suit penetration grade and viscosity characteristics of asphalt cement, ambient temperature, and workability of mixture.
   3. Accurately weigh or measure dry aggregates and weigh or meter asphalt cement to comply with job-mix formula requirements.

E. Mix aggregate and asphalt cement to achieve 90-95 percent coated particles for base mixtures and 85-90 percent coated particles for surface mixture, per ASTM D2489.

3.6 EQUIPMENT

A. Bituminous Pavers:
   1. Self-propelled, spreads without tearing surfaces, equipped with an activated screed assembly, heated if necessary, controls pavement edges to true lines without use of stationary forms and capable of spreading and finishing the asphalt plant mix material in widths applicable to the typical sections and thicknesses shown in the contract documents.
   2. Pavers used for roadway shoulders, recreational paths and similar construction will be capable of spreading and finishing the courses of asphalt plant mix material in width shown in the contract documents.
   3. Pavers will be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line, and maintaining the screed at the specified longitudinal grade and transverse slope. The sensor will be constructed to operate from either or both sides of the paver and will be capable of working with the following devices:
      a. Ski-type device at least 30 feet in length
      b. Short ski or short shoe
      c. At least 5,000 feet of control line and stakes.
   4. The controls will be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent.
   5. Manual operation will be permitted:
      a. For constructing irregularly shaped or minor areas
      b. If the automatic controls fail or malfunction the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained. However, if specified surface tolerances cannot be achieved, paving operations will be suspended until satisfactory correction, repairs of equipment replacements are made.

B. Rolling Equipment
   1. Steel-wheel roller: Self-propelled, contact pressure of 250 to 350 psi per inch of width of roller wheel, equipped with adjustable scrapers and means for keeping wheel wet to prevent mix from sticking.
   2. Pneumatic-tired rollers: Self-propelled, contact pressure under each tire of 85 to 110 psi, wheels spaced so that one pass will accomplish one complete coverage equal to rolling width of machine, oscillating wheels. Remove and replace immediately tires picking up fines.
C. Hand Tools: Provide rakes, lutes, shovels, tampers, smoothing irons, pavement cutters, portable heaters, and other miscellaneous small tools

3.7 PLACING THE MIX

A. Place asphalt concrete mixture on prepared surface, spread and strike-off using paving machine

B. Complete placement over full width of section on each day’s run

C. Spread mixture at minimum temperature specified by CDOT Table 401-5 for the specific binder used in the asphalt mix:
   1. PG 64-22: 320 F minimum mix discharge temperature, 235 F minimum delivered mix temperature
   2. PG 58-28: 275 F minimum mix discharge temperature, 235 F minimum delivered mix temperature
   3. The maximum mix discharge temperature will not exceed the minimum discharge temperature by more than 30 F.
   4. Delivered mix temperature will be measured behind the paver screed
   5. Hot asphalt mixture will be produced at the lowest temperature with the specified temperature range:
      a. producing a workable mix and provides for uniform coating of aggregates, in accordance with AASHTO T195
      b. allowing the required compaction to be achieved

D. Inaccessible and small areas may be placed by hand

E. Conform to the grade, cross section, finish thickness, and density indicated.

F. Lift Thickness
   1. Place in multiple lifts. Place asphalt in lifts such that each compacted lift thickness is no less than 2.0" thick and no greater than 3.0" thick. Top lift to be 2" thick.
   2. Typical Lift Thickness Sequencing:

<table>
<thead>
<tr>
<th>Final Asphalt Section Required (inches)</th>
<th>No. of Lifts</th>
<th>Thickness of each Lift (inches) from bottom to top lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3&quot;</td>
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<td>4</td>
<td>3-3-2-2</td>
</tr>
<tr>
<td>&gt;10</td>
<td>Review with Engineer</td>
<td></td>
</tr>
</tbody>
</table>

G. Paver Placing
   1. Unless otherwise directed, being placing along centerline of areas in crowned section and at high side on one-way slope and in direction of traffic flow
   2. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips
   3. Complete base courses before placing surface courses
   4. Place mixture in continuous operation as practicable

H. Hand Placing
   1. Spread, tamp, and finish mixing using hand tools in areas where machine spreading is not possible as acceptable to Engineer
   2. Place mixture at a rate that will insure handling and compaction before mixture becomes cooler than acceptable working temperature
I. Joints
1. Construct transverse joint at right angles to centerline when operations are suspended long enough for mixture to chill
2. Construct joints to have same texture, density, and smoothness as adjacent sections of asphalt concrete course
3. Clean contact surfaces free of sand, dirt, or other objectionable material and apply tack coat
4. Offset transverse joints in succeeding courses not less than 24 inches
5. Cut back edge of existing pavement or previously placed course to expose an even, vertical surface for full course thickness
6. Offset longitudinal joints in succeeding courses not less than 6 inches
7. When the edges of longitudinal joints are irregular, honeycombed or inadequately compacted, cut back unsatisfactory sections to expose an even, vertical surface for full course thickness
8. Wearing course constructed in even number of strips; place 1 longitudinal joint on centerline of road
9. Wearing course constructed in odd number of strips; place the centerline of 1 strip on centerline of road

J. Gutter: Finish surface high adjacent to concrete gutter so when compacted surface is slightly higher than edge of curb and flashing

3.8 COMPACTING THE MIX

A. All paving will be compacted to 94 +/- 2% of Maximum Theoretical (RICE) density, CP-51 or AASHTO T209: Maximum Specific Gravity of Bituminous Paving Mixtures, as determined by ASTM D 2950. RICE values will be used in calculating Relative Compaction according to CP-44 or AASHTO T166.

B. Provide pneumatic and steel-wheel type rollers to obtain the required pavement density, surface texture and rideability

C. Begin rolling operations when the mixture will bear weight of roller without excessive displacement and complete as quickly as possible after placement occurs.

D. Compaction operations will be continuous until the required density is achieved or the density requirements are not met and the mix temperature falls below 185˚ F or there is obvious surface distress or breakage. Minimum compaction temperatures may be adjusted according to the asphalt binder supplier recommendations. Adjusted minimum compaction temperatures must be shown on the approved mix design or on the asphalt binder supplier documentation kept on file at the jobsite.

E. Do not permit heavy equipment, including rollers to stand on finished surface before it has thoroughly cooled or set

F. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers

G. Start rolling longitudinally at extreme lower side of sections and proceed toward center of pavement. Roll to slightly different lengths on alternate roller runs

H. Do not roll centers of sections first under any circumstances

I. Breakdown Rolling
1. Accomplish breakdown or initial rolling immediately following rolling of transverse and longitudinal joints and outside edge
2. Operate rollers as close as possible to paver without causing pavement displacement
3. Check crown, grade, and smoothness after breakdown rolling
4. Repair displaced areas by loosening at once with lutes or rakes and filling, if required, with hot loose material before continuing rolling

J. Second Rolling
1. Follow breakdown rolling as soon as possible, while mixture is hot and in condition for compaction
2. Continue second rolling until mixture has been thoroughly compacted
K. Finish Rolling
   1. Perform finish rolling while mixture is still warm enough for removal of roller marks by combination of steel and pneumatic rollers
   2. Continue rolling until roller marks are eliminated and course has attained specified density, and required surface texture and surface tolerances
   3. After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled and attained its maximum degree of hardness

L. Patching
   1. Remove and replace defective areas
   2. Cut-out and fill with fresh, hot asphaltic concrete
   3. Remove deficient areas for full depth of course
   4. Cut sides perpendicular and parallel to direction of traffic with edges vertical
   5. Apply tack coat to exposed surfaces before placing new asphaltic concrete mixture
   6. Compact by rolling to specified surface density and smoothness

3.9 JOINING TO EXISTING WORK

A. Cut sides vertically and apply tack coat to exposed asphalt surfaces before placing new pavement. Meet existing thickness of surface and base courses, but not less than specified for new work.

B. All joins shall be compacted to 92.0% +/- 2.0% of RICE, taken fully on each side of joint, every 200 lineal feet. RICE values shall be used in calculating Relative Compaction according to AASHTO T166.

3.10 FIELD QUALITY CONTROL

A. The Town of Berthoud will engage a certified testing agency to perform field testing to determine compliance of in-place asphaltic concrete paving materials and compaction in accordance with Division One Specifications.

B. It is the Contractor’s responsibility to initiate, coordinate and accommodate all required tests and inspections including conformance with requirements of all applicable public agencies and authorities. Contractor will be responsible for coordinating the testing requirement with testing agency and provide the testing agency contractually required advance notification to schedule tests.

C. Testing Agency will test in-place pavement for density and thickness.

D. Asphalt density testing:
   1. Every one-hundred fifty (150) lineal feet per driving lane.
   2. Every 2,000 square feet of parking lot
   3. Densities shall be between ninety-two percent (92%) and ninety-six percent (96%) of the RICE unit weight

E. Contractor to verify final surfaces are of uniform texture, conforming to required grades and cross sections

F. The Contractor will core the pavement as required by the testing agency for field density tests in accordance with AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with ASTM D 2950.
   1. Testing agency will take not less than 4-inch diameter pavement specimens
   2. At the testing agency’s discretion, cores may be required at the beginning of placement of each pavement layer or change of mixture materials or gradation.
   3. Untested areas during placement will require cores to be taken to verify compaction
   4. Contractor to repair holes from test specimens

G. For each completed course or from locations directed by the testing agency, and at a minimum, a representative asphalt pavement sample shall be taken from the first one thousand (1,000) tons, and all mix properties shall be verified. The percent voids filled with asphalt cement, Hveem stability, and Lottman
shall be verified at a minimum of every ten-thousand (10,000) tons. Asphalt testing shall comply with ASTM D1559. Two copies of all test reports shall be submitted directly to the Engineer.

H. Acceptable density of in-place course materials is between 92 and 96 percent of the recorded laboratory RICE unit weight. Immediately re-compact asphaltic concrete not conforming to acceptable density. Remove and replace all sections not in conformance density requirements.

I. Thickness: Variations from drawings
   1. Base course: 1/4-inch +
   2. Remove and replace paving less than minimum thickness

J. Grade Tolerance: ±0.1 feet

K. Surface Smoothness
   1. Test using a 10-foot straight edge applied parallel to direction of drainage
   2. Advance straight edge five feet, maximum 1/4-inch per foot from nearest point of contact
   3. Do not permit pockets or depressions where water may pool
   4. Remove and replace areas, deficient in smoothness. Overlay corrections may be permitted only if acceptable to Engineer

L. Inspection: The work of this section is subject to the inspection and approval of the engineer and/or owner. The following inspections are required:
   1. Protection of adjacent property
   2. Staking and establishment of elevations
   3. Establishment and compaction of subgrade
   4. Placement and compaction of bituminous base course and wearing surface
   5. Final inspection
   6. Obtain approval of each element of work listed above in sequence of its completion before proceeding with the next item

3.11 CLEANING

A. After completion of paving operations, clean surfaces of excess or spilled asphalt materials to the satisfaction of Engineer

3.12 PROTECTION OF FINISHED WORK

A. After final rolling, do not permit vehicular traffic on asphalt concrete pavement until it has cooled and hardened and in no case sooner than 6 hours

B. Provide barricades and warning devices as required to protect pavement and the general public

3.13 WARRANTY

A. Provide installer’s 2-year written warranty endorsed by the contractor warranting the pavement from creeping, shoring, cracking, softening, settling, ponding and other defects due to improper placing or defective materials. Replace defective materials upon notification by the owner in accordance with the requirements of the original work.

3.14 SCHEDULE OF MIX PLACEMENT:

A. Refer to Drawings for asphalt thickness and subgrade requirements.
SECTION 32 1300
RIGID PAVING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Forming, jointing, placing and curing of concrete pavements, curbs, gutters, cross pans, islands and sidewalks.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M171 – Sheet Materials for Curing Concrete

B. American Concrete Institute (ACI)
   1. 214 – Recommended Practice for Evaluating Compression Test Results of Field Concrete
   2. 301 – Specifications for Structural Concrete for buildings
   3. 304 – Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
   4. 305/305R – Hot Weather Concreting
   5. 306/306R – Cold Weather Concreting
   6. 308 – Standard Practice for Curing Concrete

C. American Society for Testing and Materials (ASTM)
   1. A1064 – Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed for Concrete
   2. A615 – Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   3. C31 – Making and Curing Concrete Test Specimens in the Field
   4. C33 – Concrete Aggregates
   5. C39 – Test Method for Compressive Strength of Cylindrical Concrete Specimens
   6. C94 – Ready Mix Concrete
   7. C143 – Test Method of Slump of Hydraulic Cement Concrete
   8. C150 – Portland Cement
   9. C260 – Air-Entraining Admixtures for Concrete
   10. C309/AASHTO M148 – Liquid Membrane-Forming Compounds for Curing Concrete
   11. C494 – Chemical Admixtures for Concrete
   12. C618 – Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
   13. C1116 – Fiber Reinforced Concrete
   14. D994 – Preformed Expansion Joint Filler for Concrete (Bituminous Type)
   15. D6690 – Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
   16. C979 – Pigments for Integrally Colored Concrete
   17. D1751 – Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction
   18. D1752 – Preformed Sponge Rubber Cork Expansion and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
   19. D7508 – Polyolefin Chopped Stands for Use in Concrete

D. CABO/ANSI A117.1 for accessibility requirements related to walks, ramps, parking areas, drives, curb ramps, etc.

E. Town of Berthoud construction specifications, standards and details.
1.3 SUBMITTALS

A. Provide under provisions of Division One Specifications

B. Product Data: Provide sufficient information on mix design and products specified to verify compliance with specifications. Provide data on joint filler admixtures and curing compounds
   1. Existing data on proposed design mixes, certified and complete
   2. Submit reports of field quality control testing

1.4 QUALITY ASSURANCE

A. Perform work in accordance with ACI 301, Conform materials and installation to applicable portions of Colorado Department of Transportation, and the Town of Berthoud construction specifications, standards and details.

1.5 REGULATORY REQUIREMENTS

A. For work on public streets or rights-of-way conform to the requirements of Town of Berthoud construction specifications, standards and details for the Construction of Curbs, Gutters, Sidewalks, Driveways, Street Paving, and other public right-of-way Improvements.

B. Comply with applicable requirements of CABO/ANSI A117.1 for accessibility requirements related to walks, ramps, parking areas, drives, curb ramps, etc.

C. Obtain cementitious materials and aggregate from same source for all work

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle materials under provisions of Division One Specifications

B. Reinforcing steel: Store on supports which will keep materials from contact with the ground and cover

C. Rubber and plastic materials: Store in a cool place, do not expose to direct sunlight

D. Prepare a delivery ticket for each load of ready-mixed concrete

E. Contractor shall submit tickets for all concrete delivered to site:
   1. Quantity delivered
   2. Actual quantity of each material in batch
   3. Outdoor temp in the shade
   4. Time at which cement was added
   5. Numerical sequence of the delivery
   6. Quantity of water that can be added in the field based on mix design
   7. Free moisture in fine and coarse aggregate in percent by weight
   8. Temperature of batch

1.7 ENVIRONMENTAL REQUIREMENTS

A. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen

B. Protect concrete from rapid loss of moisture during hot water placement
PART 2   PRODUCTS

2.1 MATERIALS

A. Form Materials
   1. Form Materials: Plywood: PS 1, waterproof resin-bonded, exterior type Douglas Fir; face adjacent to concrete Grade B or better
   2. Fiberboard: FS LL-B-810, Type IX, tempered, waterproof, screen back, concrete form hardboard
   3. Capable of supporting loads imposed by construction equipment, straight and free from warp. Clean and strong enough to resist pressure of concrete when placed and retain horizontal and vertical alignment. Coat forms with a non-staining form release agent that will not discolor or deface the surface of the concrete
   4. Joint filler: ASTM D1751 or D1752 type; 3/4-inch thick unless indicated otherwise

B. Reinforcement
   1. Where reinforcement is specified herein or indicated on the plans:
      a. Bars: ASTM A615, Grade 60
         i) Furnish in flat sheets
      c. Dowels: ASTM A615; 40 ksi yield, Grade 60, plain steel, unfinished finish
      d. Fibrous reinforcement: Collated, fibrillated, polypropylene fibers, tensile strength 70,000 psi
         i) ASTM C1116 and ASTM D7508
         ii) Use minimum of 1.5 pounds per cubic yard
         iii) Fibermesh or accepted substitution

C. Weed Control: First application, “Roundup.” Second application, Casoron “W-50" or “G-10” with colored marker dye, manufactured by Pacific Coast Borax Company or an accepted substitute of non-flammable type.

2.2 ACCESSORIES

A. Curing Compound: ASTM C309, AASHTO M-148, white pigmented liquid membrane

B. Joint Sealers: Polyurethane base, elastomeric, self leveling, chemical cure, handling 50% joint movement; Sikaflex-2C-SL or accepted substitutions

C. Sheet Materials: AASHTO M171, 4 mil

D. Expansion Joint Material: 0.5-inch thick, ASTM D1751, asphalt impregnated fiber board, glass fiber or sponge, or closed cell polyethylene foam; Texmastic “vinylex 3600,” Sonneborn “Sonoflex F,” or accepted substitutions

2.3 CONCRETE MIX

A. Comply with ASTM C94

B. Maximum Coarse Aggregate Size: 1-inch

C. Portland Cement: ASTM C150, Type V; 555 pounds minimum per cubic yard of concrete

D. Water/Cementitious Material (Cement and Fly Ash) Ratio: Less than or equal to 0.45

E. Slump: 4-inch maximum
1. May be increased to 4.5 inches for hand work, acceptable to Engineer
2. As low as possible consistent with proper handling and thorough compaction

F. Volumetric Air Content: 6.0%±1% after placement for 1-inch aggregate
   1. Vary air content with maximum size aggregate, ASTM C94, Table 3.

G. Strength: Compressive strength as determined by ASTM C39, 4,500 psi minimum at 28 days

H. Consistency: Uniform slump, suitable for the placement conditions with aggregate floating
   uniformly throughout the concrete mass, flowing sluggishly when vibrated or spaded

I. Adjust mix as required to meet specifications

J. Approved fly ash may be substituted for ASTM C150 cement up to a maximum of 25 percent Class
   C or Class F by weight of the cementitious material content. Fly ash for concrete shall conform to
   the requirements of ASTM C618 with the following exceptions:
   1. The loss on ignition shall not exceed 3.0 percent
   2. The CaO in Class F fly ash shall not exceed 18 percent

K. Admixtures: Content, batching method, and time of introduction in accordance with the
   manufacturer's recommendations for compliance with this specification
   1. Include a water reducing admixture
   2. Calcium chloride content shall not exceed 0.05% of the cement content by weight

L. COLORING [COORDINATE WITH ARCHITECT AND LANDSCAPE ARCHITECT]
   1. ASTM C979 pure mineral pigments, specially formulated for concrete coloring as manufactured
      by Davis Colors, L.M. Scofield Co., Tamm's or acceptable substitution.
   2. Colors: As Selected by the Landscape Architect. Provide submittals, samples and 5’x5’ test
      area for each color for approval prior to construction. Assume not less than 4 pounds of color
      admixture per cubic foot of Type II cement.

2.4 SOURCE QUALITY CONTROL AND TESTS

A. Provide under provisions of Division One Specifications

B. Submit proposed mix design to Engineer for review prior to commencement of work

C. Tests on cement and aggregates will be performed to ensure conformance with specified
   requirements

D. Test samples in accordance with ACI 301.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads

B. Verify gradients and elevations of base are correct

C. Check completed formwork for grade and alignment to the following tolerances:
   1. Top of forms not more than 1/8-inch in 10 feet
   2. Vertical face on longitudinal axis, not more than 1/4-inch in 10 feet
3.2 PREPARATION

A. Subgrade
   1. Prepare subgrade in accordance with Section 31 00 00 – Earthwork
   2. Moisten subgrade to depth of 6 inches at optimal moisture not more than 12 hours prior to placement to minimize absorption of water from fresh concrete
   3. Check for soft spots by proof-rolling or other means prior to setting forms. Remove soft yielding material and replace. Compact to specifications under provisions of Section 31 00 00 – Earthwork.
   4. Check crown and/or elevation of subgrade to assure specified thickness. Compact to specification additional material used to bring to correct elevation. Remove excess material where subgrade is too high
   5. Clean subgrade of all loose materials before placement of concrete. Do not disturb area inside forms after fine grading is complete
   6. Weed Control:
      a. If weeds or vegetation exist at or on the subgrade, apply “Round-up” at rates following manufacturer’s instructions. Apply “Round-up” three days prior to removal of vegetation, subgrade preparation and application of Casoron as described below to allow “Round-up” to kill all vegetation. Remove all living and dead weeds, root balls, tree/shrub roots, vegetation, and/or any organic matter from on or in the subgrade per applicable earthwork specifications prior to subgrade preparation and paving at all areas to be paved.
      b. After all fine grading, checking, shaping, and compacting of the subgrade has been completed, and just prior to placing pavement, all subgrade soil in the area to receive pavement shall be thoroughly treated with Casoron soil sterilant (in addition to “Round-up” and regardless of presence of existing weeds or vegetation). Casoron shall be thoroughly sprinkled to distribute the chemical through the first two or three inches of the subgrade. For all areas to be paved, apply Casoron weed control at a minimum rate per 100 square yards of 2.4 pounds for G-10 or 4.0 pounds for 50w at rates and methods recommended by manufacturer within one day of paving.
      c. The Contractor shall provide all necessary protection to prevent injury to animal, fish, or plant life and property occasioned by the application of the soil sterilant. Apply on a calm, wind-free day. The Contractor will be held responsible for all application of soil sterilant or the storage of same. Protect existing and new trees and shrubs beyond the limit of paving from damage due to weed killer or soil sterilant overspray or root contact. Extra caution is required to prevent over-application of products in areas to be paved under tree canopies. Trees and shrubs damaged or killed by weed killer or sterilant application shall be replaced by the contractor at contractor’s expense.
      d. Do not apply within 20 feet of trees or shrubs

B. Frame Adjustment
   1. Coat surfaces of manhole and catch basin frames with oil to prevent bond with concrete pavement for concrete collars
   2. Set frames of structures in full grout bed to provide bearing. Set to final grade
   3. Form construction joints and blockouts as indicated on drawings

3.3 PERFORMANCE AND INSTALLATION

A. Transporting mixed concrete
   1. Transporting of mixed concrete shall conform to ACI 305R
   2. Do not exceed manufacturer’s guaranteed capacity of truck agitators. Maintain the mixed concrete in a thoroughly mixed and uniform mass during handling
   3. Do not incorporate additional mixing water into the concrete during hauling or after arrival at the delivery point, unless ordered by the Engineer. If additional water is to be incorporated into the concrete, revolve the drum not less than 30 revolutions at mixing speed after the water is added and before placing concrete.
4. Furnish a water measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix on the site by the Engineer
5. Provide delivery ticket and comply with delivery requirements of this section

B. Forming
1. Place and secure forms to correct location, dimension, profile, and gradient
2. Install sufficient quantity of forms to allow continuous progress of work so that forms can remain in place at least 24 hours after concrete placement
3. Join neatly and mechanically tamp to assure firm placement. Assemble formwork to permit easy stripping and dismantling without damaging concrete
4. Oil forms prior to concrete placement
5. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement
6. Set dowels, expansion joints, preformed construction joints and header boards as specified or indicated on the drawings
7. Low roll or mountable curbs may be formed without the use of face form by using a straight edge and template to form curb face
8. Backfill behind forms as required to prevent water from entering subgrade

C. Reinforcement
1. Add fiber reinforcement to mix at plant prior to delivery to jobsite. Mixing shall be as recommended by the manufacturer to distribute the product evenly throughout the concrete mix
2. Place bar or WWF reinforcement at mid-height of slabs-on-grade or as shown on the drawings
   a. Install in as long lengths as possible. Lap adjoining pieces at least one full mesh and lace with wire
   b. Support with metal chairs, brick or stone is unacceptable
3. Hold all tie and marginal dowels in proper position by sufficient supports or pins
4. Mechanically install dowels or place on supports if center longitudinal joint is sawed in lieu of placing plastic strip
5. Interrupt reinforcement at expansion joints
6. Place dowels to achieve pavement and curb alignment as detailed.
7. Provide doweled joints inch at interruptions of concrete with one end of dowel set in capped sleeve to allow longitudinal movement
8. Grease dowels on one side of joints with caps on greased end

D. Placing concrete
1. Place concrete in accordance with ACI 301
2. Lightly moisten subgrade or base course immediately before placing concrete.
3. Ensure reinforcement, inserts, embedded parts, and formed joints are not disturbed during concrete placement
4. Deposit concrete near final position. Minimize segregation and damage to subgrade
5. Place concrete continuously over the full width of the panel and between predetermined construction joints. Spread mechanically to prevent segregation and separation of materials
6. Consolidate concrete with vibrators and spade next to forms to remove air spaces or honeycombs
7. Do not place concrete in forms that has begun to set
8. Do not place more concrete in one day than can be finished before dark the same day
10. Curbs and Gutters: Automatic machine may be used for curb and gutter placement at Contractor’s option. If machine placement is to be used, submit revised mix design and laboratory test results which meet or exceed minimums specified. Machine placement must produce curbs and gutters to required cross-section, lines, grades, finish, and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete as specified
11. Walks: Construct sidewalks with a minimum thickness of 4-inch. Tool edges to rounded profile and finish as specified or as shown on the drawings. Pitch walks 1/4-inch per foot for cross drainage unless otherwise indicated.

E. Cold weather concreting
1. Conform to ACI 306/306R, except as modified herein
2. Minimum concrete temp at the time of mixing

<table>
<thead>
<tr>
<th>Outdoor Temp at Placement (in shade)</th>
<th>Concrete Temp at Mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30°F</td>
<td>70°F</td>
</tr>
<tr>
<td>Between 30°F &amp; 45°F</td>
<td>60°F</td>
</tr>
<tr>
<td>Above 45°F</td>
<td>45°F</td>
</tr>
</tbody>
</table>

3. Do not place heated concrete which is warmer than 80 degrees F
4. If freezing temp are expected during curing, maintain the concrete temp at or above 50 deg F for 5 days or 70 deg F for 3 days with forms in place
5. Do not allow concrete to cool suddenly

F. Hot weather concreting
1. Conform to ACI 305/305R, except as modified herein
2. At air temp of 90 degrees F and above keep concrete as cool as possible during placement and curing. Fog sprayers or special wetting agents may be required for protection
3. Do not allow concrete temperature to exceed 70 deg F at placement
4. Prevent plastic shrinkage cracking due to rapid evaporation of moisture
5. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 lbs per sq ft per hr as determined from ACI 305, Fig 2.1.4

G. Joints
1. Provide concrete joints per CDOT Standard Details
2. Sidewalk and pavement
   a. Contraction joints: At intervals not to exceed 10 feet and 1 1/2 inches deep, tooled or sawcut
   b. Expansion joints: 1/2-inch premolded joints where sidewalks end at curb returns, against fixed objects, at points of sharp radius, and between sidewalk and driveway slabs. Place expansion joint at minimum of every 100 feet.
   c. Construction joints: At all separate pours, and around all appurtenances such as manholes, utility poles, and other penetrations extending into and through sidewalks. Place backer rod and polyurethane sealant for entire joint length
3. Curb and Gutter
   a. Contraction joints: At intervals not to exceed 10 feet made by insertion of 1/8-inch template at right angles to curb and 1 1/2-inch deep.
   b. Expansion joints: At curb returns, against fixed objects, at points of sharp radius, between adjacent sidewalk and curb at all curb returns, between sidewalk and all driveway slabs, and along straight lengths every 200 linear feet. Install expansion joint filler between concrete sidewalks and any fixed structure. Extend expansion joint material for full depth of concrete, except stop 1/2-inch below finish surface.
   c. Construction joints: At all separate pours, place backer rod and polyurethane sealant for entire joint length.
4. Place expansion joint filler between paving components and buildings or other appurtenances at temperatures above 50 deg F. Clean all dust, debris and water from joint. Recess top of filler 1/2-inch for sealant placement.
5. Provide keyed joints as indicated in details.
H. Finishing
1. Run straight-edge over forms with sawing motion to fill all holes and depressions.
2. After striking-off and consolidating concrete, smooth surface by screeding and floating. Use hand methods only where mechanical floating is not possible. Adjust floating to compact surface and produce uniform texture.
3. After floating, test surface for trueness with a 10’ straightedge. Distribute concrete as required to remove surface irregularities, and re-float repaired areas to provide a continuous smooth finish.
4. Finish surfaces with a wooden or magnesium float. Plastering of surfaces is not permitted.
5. Immediately after float finishing, slightly roughen the concrete surface by brooming in the direction perpendicular to the main traffic route. Use fine hair fiber-bristle broom unless otherwise directed. Coordinate the required final finish with the Engineer before application.
6. On inclined slab surfaces and steps, provide a coarse, non-slip finish by scoring surface with a stiff-bristled broom, perpendicular to line of traffic.
7. Edge all outside edges of the slab and all joints with a 0.25-inch radius edging tool.
8. Work edges of gutters, back top edge of curb, and formed joints with an edging tool, and round to 0.5-inch radius, unless otherwise indicated. Eliminate tool marks on concrete surface.
9. Brush with soft bristle brush to remove trowel marks and leave a uniform appearance just before concrete takes initial set.
10. Direction of Texturing:
   a. Curb and Gutter: At right angles to the curb line
   b. Sidewalk: At right angles to centerline of sidewalk.
11. Place curing compound on exposed concrete surfaces immediately after finishing. Apply under pressure at the rate of one gallon to not more than 135 square feet by mechanical sprayers in accordance with manufacturer's instructions acceptable to Engineer.

I. Joint sealing
1. Seal joints and clean concrete prior to opening to traffic.
2. Seal all expansion joints.
3. Separate concrete from other structures with 3/4-inch thick joint filler.
4. Place joint filler in concrete pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
5. Extend joint filler from bottom of pavement to within 1/4-inch of finished surface.

J. Curing and protection
1. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
2. Have plastic sheeting, straw, burlap and/or canvas materials available at all times to protect fresh uncured surfaces from adverse weather conditions.
3. Do not permit pedestrian traffic over sidewalks for 7 days minimum after finishing. Do not permit vehicular traffic over pavement for 14 days minimum after finishing or until 75 percent design strength of concrete has been achieved.

3.4 FIELD QUALITY CONTROL

A. Comply with Division One Specifications - Quality Assurance: Field inspections and testing

B. It is the Contractor’s responsibility to initiate, coordinate and accommodate all required tests and inspections including conformance with requirements of all applicable public agencies and authorities. Contractor will be responsible for coordinating the testing requirement with testing agency and provide testing agency contractually required advance notification to schedule tests.

C. Tolerances
1. Division One Specifications - Quality Assurance: Tolerances
2. Maximum Variation of Surface Grade: 1/4-inch in 10 ft
3. Maximum Variation from True Alignment: 3/8-inch in 10 ft
D. Take cylinders and perform slump and air entrainment tests as required by Division One Specifications in accordance with ACI 301. Unit weight and mix temperature will also be taken.

E. The first three loads will be tested for slump and air content. If any one test fails to meet requirements, that load will be rejected and tests will continue on each load until three consecutive loads meet requirements. Thereafter, five concrete test cylinders will be taken for every 75 cu yds or less cu yds of concrete placed each day.

F. One additional test cylinder will be taken during cold weather and cured on site under same conditions as concrete it represents.

G. One slump and air entrainment test will be taken for each set of test cylinders taken.

H. Cylinders will be tested as follows: 2 at 7 days, 2 at 28 days and one at a later date, if necessary, as directed by the Engineer.

I. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

J. Thickness of fresh concrete may be checked by Owner at random. Coring will be conducted in accordance with Town of Berthoud requirements. Where average thickness of concrete is deficient in thickness by more than 0.20-inch, but not more than 1.0-inch, payment to Contractor will be adjusted based on amount indicated in schedule of values for portland cement concrete paving as specified in the following table.

<table>
<thead>
<tr>
<th>CONCRETE PAVEMENT DEFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficiency in Thickness</td>
</tr>
<tr>
<td>(Determined by Cores) INCHES</td>
</tr>
<tr>
<td>0.00 to 0.20</td>
</tr>
<tr>
<td>0.21 to 0.30</td>
</tr>
<tr>
<td>0.31 to 0.40</td>
</tr>
<tr>
<td>0.41 to 0.50</td>
</tr>
<tr>
<td>0.51 to 0.75</td>
</tr>
<tr>
<td>0.76 to 1.00</td>
</tr>
<tr>
<td>Over 1.00</td>
</tr>
</tbody>
</table>

Note: When thickness of pavement is deficient by more than one inch, and judgment of the Engineer is that area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

K. Failure of Test Cylinders or Coring Results: Engineer may order removal and replacement of concrete as required upon failure of 28-day tests or if thickness of pavement is less than 95% of specified thickness.

3.5 SCHEDULE OF CONCRETE

A. See plans for concrete thicknesses and subgrade preparation.

3.6 SCHEDULE OF CONCRETE REINFORCEMENT

A. Fiber reinforcement required for all concrete flatwork, including curb and gutter, sidewalk and pavement.
B. Rebar reinforcement required for all cross pans. Reinforce all cross pans in conformance with Town of Berthoud standards and specifications.

C. Trash pad and dumpster locations: 8-inch thick concrete with #4 rebar, 12-inches on center, each way, three inches clear on all sides.

END OF SECTION
SECTION 32 1313
CONCRETE UNIT PAVING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. The General Contract Conditions, Drawings, and Division - 1 Specification sections, apply
to Work of this section.

1.01 DESCRIPTION

A. Provide all labor, materials and equipment necessary to install new concrete unit paver
sidewalks and plazas.

1.02 RELATED SECTIONS

A. Section 321123 – Aggregate Base Course
B. Section 321313 – Concrete Paving

1.03 REFERENCES

American Society of Testing and Materials (ASTM):
A. C 33, Specification for Concrete Aggregates.
C. C 140, Sampling and Testing Concrete Masonry Units.
D. C 144, Standard Specification for Aggregate for Masonry Mortar.
E. C 936, Specification for Solid Interlocking Concrete Paving Units.
F. C 979, Specification for Pigments for Integrally Colored Concrete.
G. D 698, Test Methods for Moisture Density Relations of Soil and Soil Aggregate
Mixtures Using a 5.5-lb (2.49 kg) Rammer and 12 in. (305 mm) drop.
H. D 1557, Test Methods for Moisture Density Relations of Soil and Soil Aggregate
Mixtures Using a 10-lb (4.54 kg) Rammer and 18 in. (457 mm) drop.
I. D 2940, Graded Aggregate Material for Bases or Subbases for Highways or Airports.

1.04 QUALITY ASSURANCE

A. Manufacturer: Company specializing in the manufacture of concrete interlocking pavers for a
minimum of three (3) years.
B. Contractor Warranty: Contractor shall provide a (3) year warranty on workmanship for the
entire concrete unit paver system.
C. Manufacturer Warrant: Company must supply a (3) year product warranty.
D. Contractor & Manufacturer Warranty: The use of a deicer on the pavers shall not void either
the manufacturer’s or the contractor’s warranty.
E. Installation shall be by a contractor and crew with at least three (3) years of experience in
placing interlocking concrete pavers on projects of similar nature or dollar cost.
F. Installation Contractor shall conform to all local, state/provincial licensing and bonding
requirements.

1.05 SUBMITTALS

A. Submit copies of product drawings and data in accordance with General Conditions.
B. Submit full size sample sets of concrete paving units to indicate color, shape, and finish
selections.
C. Submit sieve analysis for grading of bedding and joint sand.
D. Submit test results from an independent testing laboratory for compliance of paving unit requirements to ASTM C 936.
E. Indicate layout, pattern, and relationship of paving joints to fixtures and project formed details.
F. Substitutions: Base bid shall not include substitutions. Substitution recommendations and associated cost savings can be submitted with bid as an alternate.
G. Manufacturer’s recommendations for winter maintenance. Provide product and application rates for snow and ice removal.

1.06 MOCK-UPS

A. Install a roughly 5 ft. x 5 ft. paver area for each paver pattern type (reference drawings). These areas shall be the standard from which the work will be judged. Consideration shall be given with regard to differences in age of materials from time of mock-up erection to time of actual product delivery. Mock-ups shall not be part of the final work.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver concrete pavers to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by fork lift or clamp lift. Unload pavers at job site in such a manner that no damage occurs to the product.
B. Sand shall be covered with waterproof covering to prevent exposure to rainfall or removal by wind. The covering shall be secured in place.
C. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.

1.08 ENVIRONMENTAL CONDITIONS

A. Do not install sand or pavers during heavy rain or snowfall.
B. Do not install sand and pavers over frozen base materials.
C. Do not install frozen sand.

PART 2 PRODUCTS

2.01 CONCRETE UNIT PAVERS

A. Concrete pavers shall be supplied by Pavestone or approved equal.

1. Concrete Unit Paver: "Holland Paver" - Pavestone CO, Contact: Kristen Tischler, 303-525-3428
   a. 3 7/8" x 3 7/8" (2) pavers spilt from (1) full size Holland Paver
   b. Pavers shall be (Vehicular) 80 mm thickness, as shown on drawings.
   c. Field Pattern: Running Bond
   d. Colors: TBD
   e. Reference construction plans for pattern and layout
B. Pavers shall meet the following requirements set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units:
   1. Average compressive strength of 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa).
   2. Average absorption of 5% with no unit greater than 7% when tested in accordance with ASTM C 140.
   3. Resistance to 50 freeze-thaw cycles when tested in accordance with ASTM C 67.

D. Pigment in concrete pavers shall conform to ASTM C 979.

E. Materials shall be manufactured in individual layers on production pallets.

F. Materials shall be manufactured to produce a solid homogeneous matrix in the produced unit.

2.02 VISUAL INSPECTION

A. All units shall be sound and free of defects that would interfere with the proper placing of units or impair the strength or permanence of the construction.

B. Minor cracks incidental to the usual methods of manufacture, or chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.

2.03 SAMPLING AND TESTING

A. Manufacturer shall provide a minimum of three (3) years testing backup data showing manufactured products that meet and exceed ASTM 936-82 when tested in compliance with ASTM C-140.

2.04 BEDDING AND JOINT SAND

A. Bedding and joint sand shall be clean, non-plastic, free from deleterious or foreign matter. The sand shall be natural or manufactured from crushed rock. Limestone screenings or stone dust shall not be used. When concrete pavers are subject to vehicular traffic, the sands shall be as hard as practically available.
B. Grading of sand samples for the bedding course and joints shall be done according to ASTM C 136. The bedding sand and joint sand shall conform to the grading requirements of ASTM C 33 as shown in Table 1.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 in. (9.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>85 to 100</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>50 to 85</td>
</tr>
<tr>
<td>No. 30 (600 µm)</td>
<td>25 to 60</td>
</tr>
<tr>
<td>No. 50 (300 µm)</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No. 100 (150 µm)</td>
<td>2 to 10</td>
</tr>
</tbody>
</table>

2.07 PAVER EDGE RESTRAINT

A. StructurEdge, aluminum paver edging, by Permaloc, 800.356.9660 or approved equal. Refer to manufacturers instructions for installation.

2.08 GEOTEXTILE FABRIC

A. Mirafi 500X Interlocking Concrete Paver Stabilization Geotextile, by Mirafi, 888.795.0808 or approved equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that all systems are operable and in working condition or prove operability in the future prior to installation of snowmelt paver section. Pressure test, video inspection, pull actual wiring, etc.- provide necessary testing to insure operable systems.

A. Verify that subgrade preparation, compacted density and elevations conform to the specifications. Compaction of the soil subgrade to at least 95% Standard Proctor Density per ASTM D 698 is recommended. Stabilization of the subgrade and/or base material may be necessary with weak or saturated subgrade soils. Bobcat and surface tractors shall be used for compaction. Hand held equipment shall be used at entrance doors near underground piping. Coordinate with Owner for approval of equipment to be used. The Owner’s Representative should inspect subgrade preparation, elevations, and conduct density tests for conformance to specifications.

D. Verify that aggregate base materials, thickness, compaction, surface tolerances, and elevations conform to the specifications. Verify that geotextile fabric has been installed in accordance with manufacturer’s recommendation and as indicated in the plans.
E. Verify location, type, installation and elevations of edge restraints around the perimeter area to be paved.

F. Verify that base is dry, uniform, even, and ready to support sand, pavers, and imposed loads.

G. Beginning of bedding sand and paver installation means acceptance of base and edge restraints.

3.02 SAND BED INSTALLATION

A. Spread the sand evenly over the base course and screed to a nominal 1 ½ in. thickness. The screeded sand should not be disturbed. Place sufficient sand to stay ahead of the laid pavers. Do not use the bedding sand to fill depressions in the base surface.

B. Install paver edge restraint as indicated on construction plans and according to manufacturer’s instructions.

C. Ensure that pavers are free of foreign materials before installation.

D. Lay the pavers in the pattern(s) as shown on the construction plans. Maintain straight pattern lines.

E. Joints between the pavers on average shall be between 1/16 in. and 3/16 in. (2 mm to 5 mm) wide.

F. Fill gaps at the edges of the paved area with cut pavers or edge units.

G. Cut pavers to be placed along edge with a double blade paver splitter or masonry saw.

H. Use a low amplitude, high frequency plate vibrator to vibrate the pavers into the sand. Use Table 3 below to select size of compaction equipment:

<table>
<thead>
<tr>
<th>Minimum Centrifugal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paver Thickness</td>
</tr>
<tr>
<td>60 mm</td>
</tr>
<tr>
<td>80 mm</td>
</tr>
</tbody>
</table>

I. Vibrate the pavers, sweeping dry joint sand into the joints and vibrating until they are full. This will require at least two or three passes with the vibrator. Do not vibrate within 3 ft. (1 m) of the unrestrained edges of the paving units.
J. All work to within 3 ft. (1 m) of the laying face must be left fully compacted with sand-filled joints at the completion of each day.

K. Post compaction, spread and sweep dry joint sand into joints continuously until full. Repeat sweeping in both directions. Wet joint sand to completely fill paving unit joints if required.

L. Sweep off excess sand when the job is complete.

M. The final surface elevations shall not deviate more than 3/8 in. (10 mm) under a 10 ft. (3 m) long straightedge.

N. The surface elevation of pavers shall be 1/8 in. to 1/4 in. (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.

O. The re-sanding as necessary of paver joints shall be accomplished by contractor for a period of 90 days after completion of work.

P. The paver surface shall have positive drainage and shall be slope away from building and site walls as indicated on the drawings and field directed by the Owner’s Representative.

3.03 FIELD QUALITY CONTROL AND COMPLETION

A. After removal of excess sand and mortar, check final elevations for conformance to the drawings.

B. Contractor Furnish additional pavers to Owner for future maintenance and repair. Contact Owner for exact quantity prior to the start of construction. Pavers shall be from the same production run as the installed materials.

END OF SECTION
SECTION 32 1540
CRUSHED STONE PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes requirements for demolition, earthwork, grading, furnishing, and placement of crushed stone paving.
   1. Furnish and place crushed stone paving, bonded with fine aggregate, constructed on a prepared underlying base course in accordance with these specifications and in conformity with the dimensions, typical cross section, and the lines and grades shown on the Contract Drawings. The locations where crushed stone paving will be used are shown on the Contract Drawings.

B. Related Sections:
   1. Division 01 Section “Layout of Work and Surveys”.
   2. Division 01 Section “Contractor Quality Control”.
   3. Division 01 Section “Erosion and Sedimentation Control”.
   4. Division 31 Section “Earth Moving”.

1.3 REFERENCES


1.4 SUBMITTALS

A. Material Analysis: Contractor shall provide copies of the following test data required by ASTM:
   1. ASTM C136 - Sieve Analysis.
   2. ASTM C127 - Specific Gravity and Absorption.
   3. ASTM C131 - L.A. Abrasion.

B. Samples: Provide a one (1) quart sample of material for approval.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas, plant materials or within critical root zones.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.
C. Rejection of material.
   1. Evidence of inadequate protection or improper handling or storage shall be cause for rejection.
   2. Any product or material exhibiting signs of damage due to nonconformity to specifications or due to delivery, storage or handling shall be rejected by the Project Manager. Contractor shall be responsible for hauling off-site and disposing of according to general conditions and codes of the governing jurisdiction.

1.6 PROJECT CONDITIONS

A. Environmental requirements: Work shall occur only when weather and soil conditions permit in accordance with locally accepted practice.

B. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with proposed crushed stone paving areas by field measurements before proceeding with work.

C. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others.

D. Existing Conditions:
   1. Utilities: Determine location of existing and proposed underground utilities. Perform work in a manner to avoid damage. Hand excavate, as required.
   2. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

E. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained.

1.7 MAINTENANCE SERVICE

A. General: Maintain Work in accordance with Division 01.
   1. Maintenance Period: Begin maintenance immediately after Work is completed. Maintain areas until the end of the Warranty period.

1.8 WARRANTY

A. See Division 01 Section “Warranty”.

PART 2 PRODUCTS

2.1 CRUSHED STONE PAVING

A. Type: Crushed granite stone or gravel. Shall be unused material free of shale, lay, friable materials, organics and debris.
   1. Size Range: 3/8 inch maximum

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>85</td>
</tr>
<tr>
<td>No. 8</td>
<td>63</td>
</tr>
<tr>
<td>No. 16</td>
<td>50</td>
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<tr>
<td>No. 30</td>
<td>39</td>
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</tbody>
</table>
2. Color: Uniform tan or as approved by the Project Manager.

2.2 SOIL STABILIZER

A. Soil stabilizer or binder: Natracil by Gail Materials or approved equal.
   1. Local supplier:
   2. Swell volume: 35 ml/gm minimum in accordance with USP procedures.
   3. 90% minimum shall pass a No. 40 mesh screen.

B. Factory blended stabilized crushed stone paving. Provide in all locations shown on the drawings.
   1. Mix crushed stone paving material with Natracil with a pug mill that includes a weigh-belt feeder.
      a. Mix fourteen (14) pounds of binder per two thousand (2,000) pounds of aggregate.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas where the Work of this Section will be performed for compliance with requirements and conditions affecting installation and performance.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within the work area.
   2. Verify that final grades are completed in accordance with the drawings.

B. Proceed with installation only after unsatisfactory conditions have been corrected and approved by Project Manager.

3.2 QUALITY CONTROL

A. Mock-up: Provide field constructed sample installation of crushed stone paving, and prepared subgrade.
   1. Mock-up to be ten foot (10’) x ten foot (10’) and located where directed by Project Manager. Mock-up shall include proposed edge and banding, and surface stabilization if specified.
   2. Project Manager shall review mock up within forty-eight (48) hours of notification by the contractor.
   3. Make necessary adjustments as directed by Project Manager.
   4. Obtain approval from Project Manager before proceeding with the Work.
   5. Retain and protect mock-up during construction as a standard for judging completed crushed stone paving work. Do not remove or destroy mock-up until work is completed.
   6. Accepted and properly maintained sample installations may remain in completed work if approved in writing by Project Manager.
   7. All work shall match accepted field mock-up.

3.3 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, turf areas, existing landscape areas, and trees from damage.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of

C. Install edging of type and in locations shown on drawings. Obtain acceptance of layout by Project Manager before excavating or installing. Make minor adjustments as required.
3.4 PLACEMENT OF CRUSHED STONE PAVING

A. Cut earthwork to width of trail/area to receive crusher fines paving to approximate depth section as specified on the Contract Drawings. Remove, haul and dispose of excess material off site, or use on-site with approval of Project Manager.

B. Complete excavation required in sub-grade before fine grading and final compaction of sub-grade is performed. Extend sub-grade compaction one foot (1') beyond proposed edge of crushed stone paving or as indicated on drawings.
   1. Where earth moving is required the sub-grade shall be compacted to ninety-five percent (95%) standard proctor within two percent (2%) of the optimum moisture.
   2. Keep areas being graded or compacted shaped and drained during construction. Ruts greater than or equal to 1-inch-deep in sub-grade shall be graded out and reshaped as required, and re-compacted before crushed stone paving placement.
   3. If the trail is part of a cross slope it should drain in the direction of the slope no greater than two percent (2%). Ensure that no low spots exist so that ponding does not occur.

C. Prior to placement of Crushed Stone Paving material, the sub-grade shall be proof rolled. Where soft spots are detected, scarify subgrade beneath Crushed Stone Paving trail to a minimum of six inch (6") depth. Moisture treat and compact to a minimum ninety-five percent (95%) proctor density as determined by ASTM D698 or AASHTO T-99. Take moisture density tests every two hundred fifty (250) lineal feet of trail or proof roll. Treat and compact sub-grade, leaving it 5-inches below final grade for placement of Crushed Stone Paving. Compact material and retest by proof rolling to achieve approval of Project Manager.

D. Install crushed stone paving only after excavation and construction work which might injure it have been completed, and after edging has been completely installed on the compacted sub-grade. Install crushed stone paving, over compacted base course in areas indicated on plan.

E. Spread crushed stone evenly to fifty percent (50%) of specified depth. Avoid segregation of aggregate and contamination with lower courses or sub-grade.

F. Compact to ninety-five percent (95%) of maximum density as determined by ASTM D1557.
   1. Maintain surface course moisture content within plus/minus three percent (± 3%) of optimum. Add water to quarry fines paving as required to achieve optimum moisture content and a uniform, compacted surface conforming to the finish grades indicated.
   2. Compact areas inaccessible to rolling by mechanical tamping.

G. Protect crushed stone paving from soil or other contaminates during and following installation.

H. Spread and compact additional crushed stone paving to achieve the required minimum compacted thickness. Compact per 3.4.F above.

3.5 PLACEMENT OF STABILIZED CRUSHED STONE PAVING

A. Complete items 3.4 A through H above using specified crusher fines material with pre-incorporated specified binder at specified application rates.

B. Do not allow traffic on stabilized crushed stone paving for two days.

3.6 MAINTENANCE AND REPAIRS:

A. Crusher Fines Paving:
   1. Areas that do not compact, become eroded or are degraded in visual quality and/or performance as determined by the Project Manager are to be removed and/or repaired. Obtain approval of repair methods from Project Manager prior to affecting repairs.
B. Stabilized Crusher Fines Paving:
   1. To repair, excavate damaged area leaving a minimum one-inch depth of existing stabilized crushed stone paving. Apply stabilized crusher fines to existing surface as described above. Compact per 3.4 F above.
   2. Do not allow traffic on repaired stabilized crushed stone paving for two days or until paving has fully cured.

3.7 CLEANUP AND PROTECTION

A. All areas shall be clean at the end of each workday.

B. The contractor shall maintain protection during installation, curing, and maintenance periods.
   1. Erect temporary fencing or barricades and warning signs as required protecting newly installed Crushed Stone Paving areas from traffic, other trades, and trespassers. Maintain fencing and barricades throughout initial maintenance period and remove with approval of Project Manager.

C. Project completion: All debris, soil, trash, and excavated and/or stripped material resulting from Crushed Stone Paving operations and unsuitable for or in excess of requirements for completing work of this Section shall be disposed of off-site.

D. Maintain protection during installation and maintenance periods. See Division 1. Treat, repair or replace damaged work as required.

3.8 QUALITY ASSURANCE

A. Refer to Division 1 Section “Quality Assurance”.

END OF SECTION
SECTION 32 1816
PLAYGROUND PROTECTIVE SURFACING

PART 1  GENERAL

PART 1 - GENERAL

1.1  RELATED DOCUMENTS

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

1.2  SUMMARY

A. This Section includes the following:
   1. Unitary synthetic poured rubber seamless surface.
   2. Engineered Wood Fiber surface.

B. Related Sections:
   1. Division 01 Section “Layout of Work and Surveys”.
   2. Division 01 Section “Contractor Quality Control”.
   3. Division 01 Section “Erosion and Sedimentation Control”.
   4. Division 01 Section “Material and Equipment”.
   5. Division 01 Section “Tree Retention and Protection”.
   6. Division 03 Section “Cast-In-Place Concrete”.
   7. Division 31 Section “Earth Moving”.
   8. Division 32 Section “Crushed Stone Paving”.
   9. Division 32 Section “Concrete Walks, Curbs, and Miscellaneous Flatwork”.
  10. Division 33 Section “Subdrainage”

1.3  DEFINITIONS

A. CPSC: U.S. Consumer Products Safety Commission

B. Critical Height: Standard measure of shock attenuation. According to Consumer Products Safety Commission (CPSC) No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."

C. SBR: Styrene-butadiene rubber.

D. EPDM: Ethylene propylene diene terpolymer rubber.

E. EWF: Engineered Wood Fiber; natural processed wood product manufactured expressly for use as a playground surface.

F. IPEMA: International Play Equipment Manufacturer’s Association.

1.4  PERFORMANCE REQUIREMENTS


C. Minimum Characteristics for EWF Surfaces: According to ASTM F 2075.
1.5 SUBMITTALS

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

B. Shop Drawings: For each playground surface system, include materials, plans, cross sections, drainage, installation, penetration details, and edge termination. Include patterns made by varying colors of surfacing.

C. Samples for Initial Selection: For each type of playground surface system indicated.
   1. Include similar samples of playground surface system and accessories involving color selection.

D. Samples for Verification: For each type of playground surface system indicated.
   1. Minimum 1-quart loose-fill surface sealed in a container.
   2. Minimum six-inch (6") by six-inch (6") Sample of synthetic rubber seamless surface.
   3. Twelve-inch (12") long by full-size cross section of border edging.
   5. Minimum six-inch (6") by six-inch (6") Sample of geosynthetic, molded-sheet drainage panel.
   6. Subdrainage materials as required by Division 33 Section “Subdrainage”.

E. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Extent of surface systems and use zones for equipment.
   2. Critical heights for playground surfaces and fall heights for equipment.

F. Qualification Data: For qualified Installer and testing agency.

G. Material Certificates: For each type of playground surface system, from manufacturer.

H. Material Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each playground surface system.

I. Product Certificates: For each type of unitary synthetic playground surface system, from manufacturer.

J. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each unitary synthetic playground surface system.

K. Warranty: Sample of special warranty.

L. Maintenance Data: Maintenance manuals to include manufacturer’s data on maintenance of playground surface system.

1.6 QUALITY CONTROL

A. Installer Qualifications: An employer of workers trained and approved by manufacturer. Installer’s Site Superintendent is to have a minimum of five (5) years of experience installing similar materials on similarly scaled projects.

B. Source Limitations: Obtain playground surface system materials, including primers and binders, from single source from single manufacturer.
   1. Provide secondary materials including adhesives, primers, and geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.


D. Testing Agency: Contractor to engage a qualified testing agency to perform tests and inspections.
E. Testing Services: Testing and inspecting of completed applications of playground surface system shall take place according to ASTM F 1292.

F. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.

1.7 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit playground surface system installation to be performed according to manufacturers' written instructions and warranty requirements.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within the specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Reduction in impact attenuation.
      b. Deterioration of surface and other materials beyond normal weathering.

   2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 ENGINEERED WOOD FIBER SURFACE

A. Engineered Wood Fiber:
   1. Random-sized wood fibers, in manufacturer's standard fiber size, approximately ten (10) times longer than wide; containing no bark, leaves, twigs, or foreign or toxic materials according to ASTM F 2075; in conformance with ASTM F 1292; graded according to manufacturer's standard specification for material consistency for playground surfaces and for accessibility according to ASTM F 1951.
   2. Certified to be in conformance with IPEMA materials standards for EWF.
   3. Products: Subject to compliance with requirements, provide one of the following or an approved equal.
      a. Fibar Group LLC (The); Fibar System.
   5. Uncompressed Material Depth: Not less than as indicated on the Contract Drawings.

2.2 SYNTHETIC TURF SURFACING

A. SYNTHETIC TURF SAFETY SURFACING
   1. Products: Subject to compliance with requirements, provide one of the following or an approved equal.
      a. Synlawn; Contact Mark Presentato, 12656 E Jamison PI Unit 10Englewood, CO 80112, 303-623-4800 or Colby Gingles, 303-623-4800.
      1) SYNAugustine x47 with 6’ fallzone pad. Envirofill infill 3 pounds per square foot.
2.3 DRAINAGE

A. Engineered Wood Fiber Underdrain System:
   1. FibarSystem 300 or approved equal, consisting of:
      a. FibarDrain:
         1) Minimum flow rate of 10gpm/ft
         2) Needle punched 100% non-woven geotextile sleeve encasing a monofilament nylon mesh.
         3) Laid out on 6'-0 centers in the direction of the grade.
      b. FibarFelt:
         1) Needle-punched 100% non-woven geotextile fabric that separates the Engineered Wood Fiber from soil below.
         2) Shall allow water to flow through, and prevent rock and soil contamination of the Engineered Wood Fiber.
         3) Shall cover the sub-grade and drainage matrix to encourage proper drainage. Seams should be overlapped 3”.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, subgrade and substrate conditions, drainage, and other conditions affecting performance of the Work.

B. Surface Substrates: Verify that substrates are satisfactory for unitary playground surface system installation and that substrate surfaces are dry, cured, and uniformly level or sloped to drain within recommended tolerances according to playground surface system manufacturer’s written requirements for cross-section profile.
   1. Concrete Substrates: Verify that substrates are dry, free from surface defects, and free of laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with playground surface system or that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by playground surface system manufacturer.
   2. Gravel Substrate: Three quarter-inch (3/4”) angular gravel drainage stone, clean and washed; depth as indicated on Contract Drawings.

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

3.2 PREPARATION

A. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

B. Concrete Substrates: Provide sound supportive surface for playground surface system.
   1. Repair unsatisfactory surfaces and fill holes and depressions.
   2. Mechanically scarify or otherwise prepare concrete substrates to achieve recommended degree of roughness.
   3. Saw cut concrete for terminal edges of playground surface systems as indicated.
   4. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through playground surface system.
C. Gravel Substrates: Provide sound supportive surface for playground surface system.
   1. Gravel substrate is to be an approved substrate as stated by the manufacturer of the final play
      surface. Provide documentation from manufacturer prior to construction of play surface.
   2. Edge boundary structures and drainage systems are to be installed prior to placement of gravel
      substrate.
   3. Place and consolidate gravel substrate within edge boundary structures shown on Contract
      Drawings. Depth as shown on Contract Drawings.
   4. Smooth gravel surface by raking. Obtain Project Manager’s approval prior to placing surface.
   5. Repair any damage to gravel surface from foot traffic prior to placing final surface.

3.3 INSTALLATION, GENERAL

A. General: Comply with playground surface system manufacturer’s written installation instructions. Install
   playground surface system over area and in thickness indicated.

3.4 DRAINAGE SYSTEMS

A. Install drainage systems as indicated on Drawings, Details, and per Division 33 Section “Subdrainage
   Systems”.

B. Installation of FibarSystem 300:
   1. Excavate area to proper depth, based on Critical Fall Height.
   2. Minimum 1% downward grade to ensure proper drainage to FibarDrain Strip.
   3. Accurately grade and firmly compact entire area, especially where fill materials have been utilized.
   4. Excavate trench 2” wide x 6” deep, perpendicular to grade at lowest point of playground area.
   5. Install FibarDrain and connect low end of strip to storm drain or similar device to remove collected
      water.
   6. Install playground equipment.
   7. Install retaining border or curb.
   8. Install FibarDrain strips at 6’ centers in direction of grade.
   9. Cover sub-grade and drainage trench with FibarFelt.
   10. Allowing 3” overlap at all seams.
       a. Slit to fit around footings of equipment.
       b. Overlap all slits with either next piece of FibarFelt or scrap piece, to ensure complete
          coverage.
   11. Install FibarMat wear mats either on FibarFelt, in middle of Fibar Engineered Wood Fiber® or on
       top of system.
   12. Permanently mark, with paint or other type of permanent marker, all the legs of the playground
       equipment with the compacted system design depth.
   13. Spread Fibar®EngineeredWood Fiber using a Bobcat, small front-end loader or our Express
       Blower Trucks.
       a. Care should be taken when driving over FibarDrain.
       b. Do not make sharp turns on FibarFelt or FibarDrain.
   15. Additional materials are supplied to account for natural compaction.
   16. Material may be several inches high, until it compacts.
   17. Feather edges to make smooth transition to grade or border.
   19. After two weeks of active use, surface should be raked again.

3.5 INSTALLATION OF ENGINEERED WOOD FIBER PLAYGROUND SURFACE SYSTEMS

A. Engineered Wood Fiber: Place playground surface system materials including manufacturer’s standard
   amount of excess material for compacting naturally with time to required depths after installation of
   playground equipment support posts and foundations.

B. Finish Grading: Hand rake to a smooth finished surface and to required elevations.
3.6 PROTECTION

A. Maintain a neat and orderly work site at all times. Upon completion of site work, clean up area, remove tools, equipment, materials and debris

END OF SECTION
SECTION 32 3300  
SITE FURNISHINGS

PART 1 GENERAL

1.1 SUMMARY

A. DESCRIPTION

1. The work in this section consists of furnishing and installing benches, tables, bicycle racks, trash and recycling receptacles, bollards, and planter pots.

B. QUALITY ASSURANCE

1. Material and craftsmanship for site furnishings shall conform to recognized association standards.
2. Contractor to submit color samples, technical data, and installation methods prior to any ordering and/or installing of these items.
3. Contractor to field locate each item and associated paving prior to any installation and/or construction and shall have Owner’s Representative’s review.

C. SUBMITTALS

1. Submit manufacturer’s technical data and installation information for approval by the Owner and Landscape Architect.

PART 2 PRODUCTS

2.1 LITTER AND RECYCLING RECEPTACLES

A. Litter and Recycling Receptacle: Dispatch Litter & Recycling Receptacle by Forms + Surfaces. Contact Nathan Erickson (T) 800-451-0410, or Landscape Architect approved alternate.
1. Model: 36 Gallon Dual Split Stream, two 16-gallon half liners
2. Lid: Litter Opening Lid
3. Finish: Powder coated, Dark Gray Metal
4. Surface Mounted with Concrete Base
5. Coordinate final locations with Owner’s Representative prior to mounting
6. Install per manufacturers detail and recommendations
7. Quantity: Per plans

2.2 BICYCLE RACKS

A. Bola Bike Rack by Landscape Forms. Contact Vivian Kovacs (T) 800-430-6206 X 1323, or Landscape Architect approved alternate.
1. Model: Bola
2. Finish: Stainless Steel
3. Surface Mounted- Coordinate final locations with Owner’s Representative prior to mounting
4. Install per manufacturers detail and recommendations
5. Quantity: Per plans
2.3 BENCH TYPE A

A. Backed Bench by Landscape Forms. Contact Vivian Kovacs (T) 800-430-6206 X 1323, or Landscape Architect approved alternate.
   1. Model: Santa Cole Neocombo Bench
   2. Finish/Material: Aluminum
   3. Color: Aluminum
   4. Mounting: Surface Mounted
   5. Install per manufacturers detail and recommendations
   6. Quantity: Per plans

2.4 BENCH TYPE B

   1. Model: Heavy-Heavy Industry Bench
   2. Finish/Material: Wood and CorTen Steel
   3. Size: 89" long x 4 Slats
   4. Mounting: Surface Mounted
   5. Install per manufacturers detail and recommendations
   6. Quantity: Per plans

2.5 PICNIC TABLE TYPE A

A. Drifter Picnic Set by Streetlife. (T) 215-247-0148, or Landscape Architect approved alternate.
   1. Model: Drifter Picnic Set
   2. Finish/Material: Wood and CorTen Steel
   3. Size: 118"
   4. Mounting: Surface Mounted
   5. Install per manufacturers detail and recommendations
   6. Quantity: Per plans

2.6 PICNIC TABLE TYPE B

A. Standard Picnic Set by Streetlife. (T) 215-247-0148, or Landscape Architect approved alternate.
   1. Model: Standard Picnic Set
   2. Finish/Material: Wood and CorTen Steel
   3. Size: 92"
   4. Mounting: Surface Mounted
   5. Install per manufacturers detail and recommendations
   6. Quantity: Per plans

2.7 PET RELIEF

A. Dog Waste Station: Dog Waste Depot (T)800.678.1612
   1. Dog Waste Station with Round Can and ONEpul Bag System
   2. Item Number: DEPOT-022-B
   3. Color: Powdercoated Black
   4. Install per manufacturer’s instructions and details
   5. Quantity: 2 – Location on plans TBD
PART 3 EXECUTION

2.1 INSTALLATION

A. All site furniture shall be installed per Drawings and manufacturer’s instructions.

END OF SECTION
SECTION 32 4000
SITE STONE

PART 1 GENERAL

1.01 Related Documents
A. The General Contract Conditions, Drawings, and Division - 1 Specification sections, apply to Work of this section.

1.02 Description
A. The work in this section consists of furnishing and installation of cobble swale, stone walls, stone outcrops, stone at playground edges, stone at terraces, and stone benches.

1.03 Related Sections
A. Section 02200 – Earthwork
B. Section 02232 – Aggregate Base Course
D. Section 04105 – Mortar and Grout

1.04 Quality Assurance
A. Source: Specified stone shall come from a single source.
B. Stone Outcrops and Stone at stairs: Prior to placement of stone material contractor shall meet on site with the Owner’s Representative to review placement and aesthetic approaches for the stone placement of each stone feature. The Contractor shall install a mockup of material, which may remain part of the work if approved by Owner’s Representative. The mockup shall constitute the area of the feature as shown on the drawings. The Contractor should anticipate rehandling of stone to achieve desired design intent.
C. Construct a sample mock up of approved materials, 15 -feet long by 3-feet high. Show color, range of stone sizes and projection, proportion, and craftwork. Owner’s representative must approve sample location prior to construction. Do not begin any other stone work until the mock-up is approved. Approved panel shall become the standard of comparison for all stone work. Do not alter, move or destroy panel until the contract is complete.
D. The firm that is employed to construct the stonework shall be customarily employed in the landscape stone masonry industry. Prior to beginning construction of the walls, the Contractor must demonstrate to the Owner’s Representative that the firm has at least three years of previous experience constructing stone walls and has completed at least five generally similar projects. The firm shall employ skilled labor with a working knowledge of stone masonry techniques. Journeyman or lead mason must have a minimum experience of 3 years.
E. The Owner’s Representative reserves the right to reject the Contractor’s masonry personnel or stonework subcontractor based on these experiences and skill requirements. If rejected, the Contractor shall obtain personnel and/or a subcontractor having qualifications acceptable to the Owner’s Representative.
F. No adjustments in prices or completion time will be allowed due to changes in personnel or delays in obtaining satisfactory personnel or subcontractor.
G. Contractor shall guarantee their respective work against defective materials or faulty workmanship as specified in the General Conditions and Division One Specifications.
H. All stone walls exceeding 3 feet height shall be mortared with joint dug out for dry look on face.

I. Contractor shall obtain mortar ingredients of uniform quality, from one manufacturer for each cementitious component and from one source and producer for each aggregate for the entire project.

J. Contractor shall comply with the following standards, except where more stringent requirements are stated on the drawings or herein:

2. American Society for Testing Materials, ASTM.

1.04 Submittals:
Submittals shall be made in accordance with the Special Conditions of the Contract. The following shall be submitted for the Work in this Section:

A. Samples: Samples shall be submitted for the following:

1. Grout colors: Provide a cut sheet of colors. Landscape Architect will select color to match stone

B. Product Data:

1. Quarry Facility: complete data on quarry facilities for stone type and on fabrication facilities for stonework. Include information of location and production capabilities
2. Photographs of the nature and character of each stone type selected
4. Type of Equipment to be used for equipment hours
5. Mix Design for Embedment Concrete

1.06 Delivery, Storage And Handling

A. Store masonry materials on platforms or pallets. Store mortar materials under cover in a dry location. Protect steel materials from moisture and keep free of loose scale and rust. Handle masonry materials carefully to avoid chipping, breakage, contact with soil or other contaminating material. Deliver cementitious materials in the manufacturer’s unbroken, labeled containers. Care shall be taken in transportation and handling of stone, so as not to scratch or damage the stone, particularly the naturally weathered surfaces.

1.07 Project Conditions

A. Hot Weather Conditions

Protect all masonry construction from direct exposure to wind and sun for 48 hours after installation when erected in an ambient air temperature of 99°F (37°C) in the shade with relative humidity less than 50%.

B. Cold Weather Conditions

Before erecting masonry during temperatures below 40°F, submit a written statement and receive approval on methods proposed to heat masonry materials and protect masonry from freezing as required hereafter. Keep masonry completely covered and free of frost, ice and snow at all times, maintain a minimum temperature of 40°F (4°C) when laid. Maintain temperature of mortar and grout between 70°F (21°C) and 100°F (43°C). Do not exceed 160°F (71°C) temperature of mixing water or of water and sand introduced to cement. Maintain air temperature on both side of
masonry above 40°F (4°C) for at least 72 hours, 48 hours if high-early strength cement is used in the mortar in lieu of Portland cement or masonry cement. Do not build upon frozen work. Do not place concrete footings on muddy or frozen surfaces.

PART 2 PRODUCTS

2.01 General
A. Upon delivering the stone to the site, Owner’s Representative will examine the stone and may reject any determined to be damaged or scratched on the desired exposed faces or unnaturally shaped. These stone shall be removed from the site at the Contractor’s expense.

B. Stone features shall incorporate a mix of shapes and sizes with bedding planes and proportions of stone in different sizes resembling the elevations shown in the drawings. Natural bedding planes of stone slab walls are to be laid horizontally; horizontal and vertical joints to be frequently interrupted. Stone shall appear naturally weathered; cut faces shall not be visible unless shown on the drawings; and sharp edges shall not be exposed.

C. The nominal sizes of boulders and stone slabs listed shall serve as the minimum acceptable dimension on any axis through the approximate center of mass of the stone. Stone with any dimension smaller than the nominal dimension stated shall be used as the next nominal size less.

D. Contractor shall notify the Owner’s Representative at a minimum 48 hours in advance of stone placement.

2.02 Stone
A. Stone slabs shall be ‘Sienna Buff’ sandstone as supplied by Siloam Stone Inc., 315 North 7th, Canon City, Colorado 81212, 719-275-4275 or approved equal.

2.03 Geotextile Fabric
A. Mirafi 140 N as supplied by TC Mirafi, 706-693-2226, or approved equal

PART 3 EXECUTION

3.01 GENERAL
A. Stone shall be placed individually in a manner to avoid displacing underlying materials or placing undue impact force on the underlying materials. Stone shall not be dropped from a height of more than 2 inches.

B. Stone shall be placed in position by the use of a multi-prong grapple device or suitable equipment for handling material. Dayline buckets and skips shall not be used for placement of stone.

C. Stone shall be placed with weathered and most natural, rounded surface up, or as directed.

D. Stone shall be placed in the presence of the Owner’s Representative, and Owner’s Representative shall approve the placement before stone are backfilled and/or mortared. The contractor should
anticipate that rehandling of individual stone after initial placement will be required to achieve required elevations and placements.

E. Backfill excavation around site boulder / stone as indicated on construction plans and in accordance with Section 02200 and 02260.

F. Excavate for placement of stone, such that top of stone slab will meet grade specified on grading plan and detail. Provide a firm, smooth, uniform surface. Contractor shall prepare subgrade as indicated in the construction plans and specifications.

G. Provide chases, reveals, reglets, openings and other spaces as shown or required for contiguous work. Close up openings in stonework after other work is in place. Use materials and set to match surrounding stonework.

H. During all seasons, protect partially completed stonework against weather when work is not in progress. Cover top of wall with strong, waterproof, non-staining membrane extending at least 2-feet down the stone face and anchor securely in place.

I. Do not build on frozen work; remove and replace stonework damaged by frost or freezing.

J. Do not use stone units with chips, cracks, voids, stains or other defects which might be visible in the finished work unless otherwise acceptable to the Owner's Representative.

A. Contractor shall cut stone slabs as required to meet desired lines, layout, and grades. Contractor shall place filler stones and grout to meet desired grades. Reference drawings for details for example of finish work.

K. Contractor shall place aggregate base course and stone slab in accordance with specifications and construction plans. Contractor shall minimize the appearance of cut stone faces. Contractor shall mortar stones in place as indicated in construction plans and as directed by Owner's Representative.

L. Set stone in accordance with drawings. Provide anchors, supports, fasteners and other attachments as shown or necessary to secure stonework in place. Adjust accessories for proper setting of stone. Completely fill slots for anchors, dowels, fasteners and supports with mortar during setting of stone. Stone walls over 3 feet high shall be mortared. Minimize appearance of all mortar.

M. Execute stonework by skilled mechanics and employ skilled stone fitters at the site to do necessary field cutting as stone is set.

3.02 Adjustment, Protection, And Clean-Up

A. Upon completion of work, remove from the premises all surplus materials, tools, equipment, rubbish, debris, and rejected stone resulting from the work.

B. Remove and replace stone units that are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units that do not match adjoining stonework. Provide new matching units; install as specified and point-up to eliminate evidence of replacement. Repoint defective and unsatisfactory joints as required to provide a neat, uniform appearance.

B. Clean stonework not less than six days after completion. Thoroughly clean and scrub completed wall with fiber brushes, using a mild alkaline abrasive cleaner that contains no caustic or harsh fillers. Do not use wire brushes or acid type cleaning agents. Begin at top and work down. Clean stone thoroughly, leaving no mortar stains or traces of cleaning compound.

C. Protect the stonework from collapse, deterioration, discoloration or damage during subsequent construction and until acceptance of the work.
END OF SECTION
PART 1 - GENERAL

1.01 WORK INCLUDED - Work of this Section generally includes provisions for the installation of an underground landscape irrigation system including the following:

A. Static pressure verification and coordination of irrigation system installation with landscape material installation.

B. Trenching, stockpiling excavation materials, refilling and compacting trenches.

C. Complete irrigation system including but not limited to piping, backflow preventer assemblies, valves, fittings, heads, controllers and wiring, and final adjustments to insure complete coverage.

D. Water connections.

E. Replacement of unsatisfactory materials.

F. Clean-up, Consultant Reviews, and Project Acceptance.

G. Tests.

1.02 REFERENCES

A. Conform to requirements of reference information listed below except where more stringent requirements are shown or specified in Contract Documents.

1. American Society for Testing and Materials (ASTM) - Specifications and Test Methods specifically referenced in this Section.
2. Underwriters Laboratories (UL) - UL Wires and Cables.
3. National Sanitation Foundation (NSF) – Piping and Backflow prevention.

1.03 QUALITY ASSURANCE

A. Installer Qualifications - Installer shall have had considerable experience and demonstrate ability in the installation of irrigation system(s) of specific type(s) in a neat, orderly, and responsible manner in accordance with recognized standards of workmanship. To demonstrate ability and experience necessary for this Project, and financial stability, submit if requested by Consultant, prior to contract award the following:

1. List of 3 projects completed in the last 2 years of similar complexity to this Project. Description of projects shall include:
   a. Name of project.
   b. Location.
   c. Owner.
   d. Brief description of work and project budget.

B. Special Requirements:

1. Work involving substantial plumbing for installation of copper piping, backflow preventer(s), and related work shall be executed by licensed and bonded plumber(s). Secure a permit at least 48 hours prior to start of installation.

2. Tolerances - Specified depths of mains and laterals and pitch of pipes are minimums. Settlement of trenches is cause for removal of finish grade treatment, refilling, compaction, and repair of finish grade treatment.

3. Coordination with Other Contractors - Protect, maintain, and coordinate Work with Work under other Section.

4. Damage To Other Improvements - Contractor shall replace or repair damage to grading, soil preparation, seeding, sodding, or planting done under other Sections during Work associated with installation of irrigation system at no additional cost to Owner.
C. Pre-Construction Conference - Contractor shall schedule and conduct a conference to review in detail quality control and construction requirements for equipment, materials, and systems used to perform the Work. Conference shall be scheduled not less than 10 days prior to commencement of Work. All parties required to be in attendance shall be notified no later than 7 days prior to date of conference. Contractor shall notify qualified representatives of each party concerned with that portion of Work to attend conference, including but not limited to Architect, Consultant, Contractor’s Superintendent, and Installer.

1. Minutes of conference shall be recorded and distributed by Contractor to all parties in attendance within five days of conference.

1.04 SUBMITTALS

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

B. Materials List - Submit five copies if submitting in hard-copy format or one full electronic set of a complete materials list indicating manufacturer, model number, and description of all materials and equipment to be used. Show appropriate dimensions and adequate detail to accurately portray intent of construction via cut sheets and/or shop drawings, as appropriate based on plans, details, and specification information contained within.

C. Record Drawings (As-Builts):

1. At onset of irrigation installation secure Autocadd files of original irrigation design from Owner. At the end of every day, revise as-built prints for work accomplished that day in red ink. As-built field prints and cadd files shall be brought up-to-date at the close of the working day every Friday by a qualified draftsman. A print of record plan(s) shall be available at Project Site. Indicate zoning changes on weekly as-built drawings. Indicate non-pressure piping changes on as-built. Upon completion of Project, but prior to scheduling of substantial acceptance walk-through, submit for review a final set of as-built mylars and an Autocadd disk copy with all equipment symbols moved to actual locations in cadd file. Dimensions, from two permanent points of reference (building corners, sidewalk, road intersections or permanent structures), location of following items:
   a. Connection to existing water lines.
   b. Routing of sprinkler pressure lines (dimension maximum 100 feet along routing).
   c. Sprinkler control valves.
   d. Quick coupling valves.
   e. Manual drains and stop and waste valves.
   f. Drip line blow-out stubs.
   g. Control wire routing if not with pressure mainline.
   h. Gate valves.
   i. Control wire and communication cable splices
   j. Water meters
   k. Locations of all sleeving including size, quantity and depth of sleeve
   l. Flow sensors
   m. Pressure regulating valves

2. Owner’s Representative will not certify any pay request submitted by the Contractor if the as-built drawings are not current, and processing of pay request will not occur until as-builts are up-dated.

D. Operation Instructions - Submit 3 written operating instructions including winterization procedures and start-up, with cut sheets of products, and coordinate controller/watering operation instruction with Owner maintenance personnel.

1. Controller Charts:
   a. Do not prepare charts until Consultant has reviewed record (as-built) drawings.
   b. Provide one controller chart for each automatic controller installed.
      i. Chart may be reproduction of record drawing, if scale permits fitting of controller door. If photo reduction prints are required, keep reduction to maximum size possible to retain full legibility.
      ii. Chart shall be blueline print of actual “as-built” system, showing area covered by that controller.
   c. Identify area of coverage of each remote control valve, using a distinctly different pastel color drawing over entire area of coverage.
   d. Following review of charts by Consultant, they shall be hermetically sealed between two layers of 20-mm thick plastic sheet
   e. Charts shall be completed and reviewed prior to final review of irrigation system.
E. Provide documentation of construction and demolition waste debris recycling / salvage rates. See Section 01 74 19 - Construction Waste Management and Disposal

1.05 DELIVERY, STORAGE, AND HANDLING

A. Comply with General Conditions and Division 1 Section "Product Requirements".

B. Deliver, unload, store, and handle materials, packaging, bundling, products in dry, weatherproof, condition in manner to prevent damage, breakage, deterioration, intrusion, ignition, and vandalism. Deliver in original unopened packaging containers prominently displaying manufacturer's name, volume, quantity, contents, instructions, and conformance to local, state, and federal law. Remove and replace cracked, broken, or contaminated items or elements prematurely exposed to moisture, inclement weather, snow, ice, temperature extremes, fire, or jobsite damage.

C. Handling of PVC Pipe - Exercise care in handling, loading and storing, of PVC pipe. All PVC pipe shall be transported in a vehicle that allows length of pipe to lie flat so as not to subject it to undue bending or concentrated external loads. All sections of pipe that have been dented or damaged shall be discarded, and if installed, shall be replaced with new piping.

1.06 JOBSITE CONDITIONS

A. Protection of Property:
   1. Preserve and protect all trees, plants, monuments, structures, and paved areas from damage due to Work of this Section. In the event damage does occur, all damage to inanimate items shall be completely repaired or replaced to satisfaction of Owner, and all injury to living plants shall be repaired by Owner. All costs of such repairs shall be charged to and paid by Contractor.
   2. Protect buildings, walks, walls, and other property from damage. Flare and barricade open ditches. Damage caused to asphalt, concrete, or other building material surfaces shall be repaired or replaced at no cost to Owner. Restore disturbed areas to original condition.

B. Existing Trees:
   1. All trenching or other Work under limb spread of any and all evergreens or low branching deciduous material shall be done by hand or by other methods so as to prevent damage to limbs or branches.
   2. Where it is necessary to excavate adjacent to existing trees use all possible care to avoid injury to trees and tree roots. Excavation, in areas where 2 inch and larger roots occur, shall be done by hand. Roots 2 inches or larger in diameter, except directly in the path of pipe of conduit, shall be tunneled under and shall be heavily wrapped with burlap to prevent scarring or excessive drying. Where a trenching machine is operated close to trees having roots smaller than 2 inches in diameter, wall of trench adjacent to tree shall be hand trimmed, making clean cuts through roots. Trenches adjacent to trees shall be closed within 24 hours, and when this is not possible, side of trench adjacent to tree shall be kept shaded with moistened burlap or canvas.

C. Protection and Repair of Underground Lines:
   1. Request proper utility company to stake exact location (including depth) of all underground electric, gas, or telephone lines. Take whatever precautions are necessary to protect these underground lines from damage. If damage does occur, Utility Owner shall repair all damage. Contractor shall pay all costs of such repairs unless other arrangements have been made.
   2. Request Owner, in writing, to locate all private utilities (i.e., electrical service to outside lighting) before proceeding with excavation. If, after such request and necessary staking, private utilities that were not staked are encountered and damaged by Installer, Owner shall repair them at no cost to Installer. If Contractor damages staked or located utilities, they shall be repaired by Utility Owner at Contractor's expense unless other arrangements have been made.

D. Replacement of Paving and Curbs - Where trenches and lines cross existing roadways, paths, curbing, etc., damage to these shall be kept to a minimum and shall be restored to original condition.

1.07 WARRANTY/GUARANTY

A. Manufacturer shall warrant materials against defects for a period of one year from date of Substantial Completion. Installer(s) shall guaranty workmanship for similar period.
B. Settling of backfilled trenches that may occur during guaranty period shall be repaired at no expense to Owner, including complete restoration of damaged property.

C. Expenses due to vandalism before substantial completion shall be borne by Contractor.

D. Owner will maintain turf and planting areas during warranty period, so as not to hamper proper operation of irrigation system.

1.08 MAINTENANCE

A. Furnish the following maintenance items to Owner prior to final Acceptance:
   1. Two Sets of special tools required for removing, disassembling, and adjusting each type of sprinkler head and valve supplied on this Project.
   2. One eight foot valve key for operation of stop and waste valve.
   3. Two six foot valve keys for operation of gate valves.
   4. Two keys for each automatic controller.
   5. Two quick coupler keys and two matching hose swivels for each type of quick coupling valve installed.
   6. Two aluminum drain valve keys of sufficient length for operation of drain valves.

B. Winterization - include cost in bid for winterizing complete system at conclusion of sprinkling season (in which system received final acceptance) within 3 days notification by the Owner. System shall be voided of water using compressed air or similar method reviewed by Consultant. Reopen, operate, and adjust system malfunctions accordingly during April of following season within 3 days of notification by Owner.

1.09 EXTRA STOCK - In addition to installed system furnish the following items to Owner:

A. 10 Pop-up spray heads with nozzles of each type used.

B. 4 Rotor heads of each type used.

C. 30 Drip emitters of each type used.

D. 2 2-wire decoder –single station units

E. 1 Hand Held Programming unit for battery operated valve assemblies

F. 10 Bubbler heads of each type used.

G. 100’ roll in-line emitter tubing of each type used.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General Piping:
   1. Pressure Supply Line (from tap on city mains to winterization tee or Stop and Drain valve prior to backflow prevention unit) – Type “K” Soft Copper (3/4” – 2 1/2”), and ductile iron (3” and larger).
   2. Pressure Supply Line (from point of connection, winterization tee or Stop and Drain valve and through backflow prevention unit - Type “K” Hard Copper (3/4” – 2 1/2”), and ductile iron (3” and larger).
   3. Pressure Supply Lines (downstream of backflow prevention units) Type “K” Hard Copper (3/4” – 2 1/2”), Class 200 PVC BE (1” - 2 1/2”) and Class 200 PVC RT (3” and larger), HDPE DR11 as noted on plans and schedule.
   4. Non-pressure Lines - Class 200 PVC BE 1” minimum size, as noted on plans.
   5. Sleeving - Class 160 PVC as noted on plans and schedule.
   7. Emitter Tubing - As recommended by emitter manufacturer.

B. Copper Pipe and Fittings:
   1. Copper Pipe - Type K, hard tempered or annealed coil.
   2. Fittings - Wrought copper, solder joint type.
   3. Joints - Soldered with solder, 45% silver, 15% copper, 16% zinc, and 24% cadmium and solidus at 1125°F and liquids at 1145°F.

C. Brass Pipe and Fittings:
   1. Brass Pipe - 85% red brass, ANSI Schedule 40 screwed pipe.
2. Fittings - Medium brass, screwed 125-pound class.

D. Ductile Iron Pipe and Fittings:
1. Ductile Iron Pipe – Centrifugal cast ductile iron in metal molds for water pipe in accordance with ANSI C151 and AWWA A21.51 with asphaltic exterior coating and interior lining and coating in accordance with ANSI C151 and AWWA A21.
2. Fittings – Mechanical joint as supplied by the pipe manufacturer and rated for working pressures of 350 psi.

E. Plastic Pipe and Fittings:
1. Identification Markings:
   a. Identify all pipe with following indelible markings:
      i. Manufacturer’s name.
      ii. Nominal pipe size.
      iii. Schedule of class.
      iv. Pressure rating.
      v. NSF (National Sanitation Foundation) seal of approval.
      vi. Date of extrusion.
2. Solvent Weld Pipe - Manufactured from virgin polyvinyl chloride (PVC) compound in accordance with ASTM D2241 and ASTM D1784; cell classification 12454-B, Type 1, Grade 1.
   a. Fittings - Standard Weight, Schedule 40, injection molded PVC; complying with ASTM D1784 and D2466, cell classification 12454-B.
      i. Threads - Injection molded type (where required).
      ii. Tees and ells - Side gated.
   b. Threaded Nipples - ASTM D2464, Schedule 80 with molded threads.
   c. Teflon Tape – All PVC male threaded fittings and nipples, excluding marlex fittings, shall receive wrapping of Teflon tape applied to threaded surfaces per pipe manufacturer’s recommendations.
   d. Joint Cement and Primer - Type as recommended by manufacturer of pipe and fittings.
3. HDPE Pipe - Pipe shall be manufactured from a pipe resin which meets ASTM D 3350-05 with a minimum cell classification of 445474C. Pipe shall be manufactured to the dimensions of ASTM F-714. The service factor to determine the pressure rating shall be 0.63. Pipe shall have a minimum pressure rating of: DR 11, 200 psi. The pipe shall contain no recycled compounds except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.
   HDPE FITTINGS:
   a. Butt Fusion Fittings - Fittings shall be made from HDPE pipe resin meeting ASTM D 3350-05 with a minimum cell classification of 445474C, Molded Butt Fusion Fittings shall have a manufacturing standard of ASTM D-3261. Molded & fabricated fittings shall have the same pressure rating as the pipe unless otherwise specified on the plans. Fabricated fittings must have the same pressure rating as the pipe; a DR less than the pipe shall be used. Fabricated fittings are to be manufactured using a Data Logger to record temperature, fusion pressure, and a graphic representation of the fusion cycle shall be part of the Quality Control records.
   b. Electrofusion Fittings - Fittings shall be made from resin or pipe meeting ASTM D 3350-05 with a minimum cell classification of 445474C; Electrofusion Fittings shall meet the manufacturing standard of ASTM F-1055. Fittings shall have the same pressure rating as the pipe or higher unless otherwise specified on the plans.
   c. Transition fittings shall be used for transition to other pipe materials (1/2” – 4”, Male NPT x Butt Fusion) and meet dual standards 4710/3608 HDPE Resin, Black; Red Brass or 304 SS Stainless Steel.
   d. Flanged and Mechanical Joint Adapters - Flanged and Mechanical Joint Adapters (4” – 12”) shall be made from materials containing resin that meets ASTM D 3350-05 with a minimum cell classification of 445474C.
   e. Transitional Stiffeners shall meet 304 SS Stainless Steel.
4. Gasketed End Pipe - Manufactured from virgin Polyvinyl Chloride compound in accordance with ASTM D2241 and ASTM D1784; cell classification 1254-B, Type 1, Grade 1.
   a. Fittings and Services Tees - Ductile iron, grade 70-55-05 in accordance with ASTM A-536. Fittings shall have deep slanted bell push-on joints with gaskets meeting ASTM F-477.
   b. Joint Restraint System – As recommended manufacturer of pipe fittings.
c. Gaskets - Factory installed in pipe and fittings, having a metal or plastic support within gasket or a plastic retainer ring for gasket.

d. Lubricant - As recommended by manufacturer of pipe fittings.

5. Flexible Plastic Pipe - Manufactured from virgin polyethylene in accordance with ASTM D2239, with a hydrostatic design stress of 630 psi and designated as PE 2306.
   a. Fittings – Insert type manufactured in accordance with ASTM D2609; PVC Type 1 cell classification 12454-B.

6. Pressure Supply Piping Locating Tape: Markline Tape, 3" wide detectable tape, NP purple in color with the words "CAUTION: RECYCLED/RECLAIMED WATERLINE BELOW" printed every 36 inches. Place 12" below finish grade.

F. Drip, Sub-Surface Irrigation Systems and Bubblers:
   1. Drip Tubing - Manufactured of flexible vinyl chloride compound conforming to ASTM D1248, Type 1, Class C, Category 4, P14 and ASTM D3350 for PE 122111C.
   2. Fittings - Type and diameter recommended by tubing manufacturer.
   3. Drip Valve Assembly - Type and size shown on Drawings.
      a. Wye Strainer - Plastic construction with 150 mesh nylon screen and 1/2 inch blowout assembly.
      b. Control Valve - 2 way, solenoid pilot operated type made of synthetic, non-corrosive material; diaphragm activated and slow closing. Include freely pivoted seat seal; retained (mounted) without attachment to diaphragm.
      c. Pressure Reducing Valve - Plastic construction as detailed.
   d. Single station 2-wire decoder.

4. Emitters - Single port, pressure compensating, press on type.

5. Sub-Surface tubing - Size and type shown on Drawings; installed as detailed.
   a. Dripline Tubing – Nominal sized one-half inch (1/2") low density, ultra-violet-resistant linear polyethylene tubing with internal pressure-compensating, continuous self-cleaning, integral drippers at specified intervals and with specified discharge rates. Emitter spacing and discharge specified on Drawings.
   b. Headers and footers – polyethylene or PVC pipe as shown on Drawings.
   c. Fittings - Type and diameter recommended by tubing manufacturer.
   d. Drip Valve Assembly - Type and size shown on Drawings.
      i. Wye Strainer - Plastic construction with 150 mesh nylon screen and 1/2 inch blowout assembly.
      ii. Control Valve - 2 way, solenoid pilot operated type made of synthetic, non-corrosive material; diaphragm activated and slow closing. Include freely pivoted seat seal; retained (mounted) without attachment to diaphragm.
      iii. Pressure Reducing Valve - Plastic construction as detailed.
      iv. Single station 2-wire decoder.
   e. Soil staples – install on all on-surface installations, spaced 3 feet on center for sandy soils, 4 feet on center for loam soils, and 5 feet on center for clay soils.

6. Bubblers - Rainbird 1400 Series or approved equal.

G. Gate Valves:
   1. Gate Valves for 3/4 inch through 2-1/2 Inch Pipe - Brass construction; solid wedge, IPS threads, and non-rising stem with cross operating handle.
   2. Gate Valves for 3 Inch and Larger Pipe - Iron body, brass or bronze mounted AWWA gate valves with a clear waterway equal to full nominal diameter of valve; rubber gasket or mechanical joint-type only. Valves shall be able to withstand a continuous working pressure of 200 psi and be equipped with a square operating nut and resilient wedge. Provide pipe restraints on gate valves 3 inches or larger as detailed.

H. Quick Coupling Valves - Brass two-piece body designed for working pressure of 125 PSI; operable with quick coupler. Equip quick coupler with locking NP purple rubber cover.

I. Valve Boxes:
   1. Gate Valves, Quick Coupling Valves, Drain Valves, Drip Line Blow-out Stubs, and Wire Splice or Stub Box - Carson Brooks #910-10, Carson Brooks #H910-12 or approved equal (including bolt) box with lid and w/ Purple Bolt Down Cover as detailed.
   2. 1 inch through 2 inch Control Valves, Master Valves, Pressure Regulating Valves and Communication Cable Splice box, Sub-meters - Carson Brooks #1419-12 box, w/ Purple Bolt Down Cover as detailed.
3. Drip Valve Assemblies and Flow Sensors - Carson Brooks #1220-12 box w/ Purple Bolt Down Cover Carson Brooks #1730-12 box, as detailed.

J. Electrical Control Wiring:
1. Low Voltage:
   a. Electrical Control Wire - AWG UFUL approved No. 14 direct burial copper wire or larger, if required to operate system as designed.
   b. Electrical Common Wire - AWG UFUL approved No. 14 direct burial copper wire or larger, if required to operate system as designed.
   c. Wire Colors:
      i. Control Wires - Red.
      iii. Master Valve Wires - Blue.
      iv. Drawing Spare Control Wires - Black.
      v. Drawing Spare Common Wires - Yellow.
   d. If multiple controllers are utilized, and wire paths of different controllers cross each other, both common and control wires from each controller shall be different colors approved by Consultant.
   e. Control Wire connections and splices shall be made with 3M DBY or King 600 DBY/R direct bury splice, or as required by the controller manufacturer.
   f. Communication Cable – Paige PE-89, P7171D-A or approved equal with 3M Gel-type connections installed within Preformed Super Serviseal Splice Kit.
2. Low Voltage – (2-Wire Decoder Cable):
   a. Electrical Control Wire - UFUL approved, Paige Wire – P7072D 12/2 or as per manufactures requirements, direct burial copper wire to operate system as designed.
   b. If multiple controllers are utilized, refer to wire routing plan for individual wire runs. Each controller shall have a wire path of a different color. Refer to plan for any additional cable color requirements.
   c. If multiple controllers are utilized, each controller shall have its own 2-wire decoder cable run, controllers cannot be connected with same 2-wire run.
   d. Loop five (5) feet minimum of 2-wire cable into all valve boxes.
   e. Control Wire connections and splices shall be made with 3M DBY or King 600 DBY/R direct bury splice, or as required by the controller manufacturer.
3. High Voltage - Type required by local codes and ordinances, of proper size to accommodate needs of equipment serviced.

K. Automatic Controller - Size and type shown on Drawings; mounted as detailed.
   1. Automatic Controller (2-Wire) - Size and type shown on Drawings; mounted as detailed.
      a. Single Station Decoders (2-Wire) - Size and type shown on Drawings; mounted as detailed.
      b. Install decoders and wire per manufacture recommendations and requirements.
      c. Grounding for all decoders and 2-wire decoder cable, to be per manufactures recommendations and requirements. Minimum one grounding assembly per every 500’ of wire or every 8th decoder and at all ends of 2-wire decoder cable run.

L. Electric Control Valves - Size and type shown on Drawings having Purple manual flow adjustment, Purple solenoids, and manual bleed nut.
   1. Single station 2-wire decoder.

M. Master Valve – Size and type shown on Drawings.

N. Flow Sensor – Size and type shown on Drawings.

O. Sprinkler Heads - As indicated on Drawings. Fabricated riser units in accordance with details on Drawings - with fittings and nipples of equal diameter as riser inlet in sprinkler body.
   1. 6” to 12” Pop-up Spray Heads: Rainbird RD-XX-PXX Series with Rainbird 1800-NP purple cap covers on all spray heads.
   2. Gear Driven Rotors: Manufactured by Rain Bird or as indicated on Drawings with check valves and NP purple reclaimed identification caps and covers on all rotor heads.
   3. Sprinkler heads shall be Rotors or High-efficiency spray nozzles as indicated on plans. No substitution shall occur without written approval.
P. Backflow Preventer - Size and type indicated on Drawings; Brass or iron construction with 150 psi working pressure.

Q. Supply Pump - Size and type indicated on Drawings. Installed per manufactures recommendations.

R. Reclaimed Water Signage:
1. Sign shall state: “CAUTION: RECLAIMED WATER – DO NOT DRINK,” and display the international “do not drink” symbol.
2. Signs shall be installed and prominently displayed at: all points of ingress, restroom facilities, around all reclaimed lakes and water features, and a maximum spacing of 500 feet within the project.
3. Signs shall be visible and legible from all directions.

EXECUTION

2.02 SITE CONDITIONS, LANDSCAPE PLAN REVIEW AND COORDINATION
A. Contractor will be held responsible for coordination between landscape and irrigation system installation. Landscape material locations shown on the Landscape Plan shall take precedence over the irrigation system equipment locations. If irrigation equipment is installed in conflict with the landscape material locations shown on the Landscape Plan, the Contractor will be required to relocate the irrigation equipment, as necessary, at Contractor’s expense.

B. Contractor is responsible to notify Consultant of any field conditions that vary from the conditions shown on the Irrigation Construction Documents. If Contractor fails to notify Consultant of these conditions, Contractor will be held responsible for all costs associated with system adjustments required due to the change in field conditions.

C. Comply with the requirements of the TEMPORARY EROSION AND SEDIMENTATION CONTROL PLAN for preparation and protection of the site.

2.03 STATIC PRESSURE VERIFICATION
A. Contractor shall field verify the static pressure at the project site, prior to commencing work or ordering irrigation materials, and submit findings, in writing, to Consultant. If Contractor fails to verify static water pressure prior to commencing work or ordering irrigation materials, Contractor shall assume responsibility for all costs required to make system operational and the costs required to replace any damaged landscape material. Damage shall include all required material costs, design costs and plant replacement costs.

2.04 INSPECTION
A. Examine areas and conditions under which Work of this Section is to be performed. Do not proceed with Work until unsatisfactory conditions have been corrected.

B. Grading operations, with the exception of final grading, shall be completed and approved by Owner before staking or installation of any irrigation system begins.

C. Underground Utilities shall be installed prior to installation of irrigation system. If irrigation installation takes place prior to utility installation, Contractor shall notify Owner of this condition in writing prior to commencement of irrigation installation.

2.05 PREPARATION:
A. Staking shall Occur as Follows:
1. Mark, with powdered lime, routing of pressure supply line and flag heads for first few zones. Contact Consultant 48 hours in advance and request review of staking. Proposed locations of all trees shall be field staked by Contractor and approved by Owner/Landscape Architect prior to Consultant review of irrigation staking. Consultant will advise installer as to the amount of staking to be prepared. Consultant will review staking and direct changes if required. Review does not relieve installer from coverage problems due to improper placement of heads after staking.
2. Contractor shall contact Consultant if field spacing varies by +/- 10% of the spacing shown on the irrigation plans. If Contractor fails to notify Consultant of variances exceeding 10%, Contractor
assumes full responsibility for the costs associated with any required system modifications deemed necessary by the Consultant or Owner.

3. If Project has significant topography, freeform planting beds, or other amenities, which could require alteration of irrigation equipment layout as deemed necessary by Consultant, do not install irrigation equipment in these areas until Consultant has reviewed equipment staking.

B. Install sleeving under asphalt paving and concrete walks, prior to concreting and paving operations, to accommodate piping and wiring. Compact backfill around sleeves to 95% Modified Proctor Density within 2% of optimum moisture content in accordance with STM D1557.

C. Trenching - Trench excavation shall follow, as much as possible, layout shown on Drawing. Dig trenches straight and support pipe continuously on bottom of trench. Trench bottom shall be clean and smooth with all rock and organic debris removed.

1. Clearances:
   a. Piping 3 Inches and Larger - Make trenches of sufficient width (14 inches minimum) to properly assemble and position pipe in trench. Minimum clearance of piping 3 inches or larger shall be 5 inches horizontally on both sides of the trench.
   b. Piping Smaller than 3 Inches - Trenches shall have a minimum width of 7 inches.
   c. Line Clearance - Provide not less than 6 inches of clearance between each line and not less than 12 inches of clearance between lines of other trades.

2. Pipe and Wire Depth:
   a. Pressure Supply Piping – 24 inches from top of pipe minimum or as noted on plans.
   b. PVC Sleevng – To match depth of sleeved material.
   c. Non-pressure Piping (rotor) - 18 inches from top of pipe.
   d. Non-pressure Piping (pop-up) - 14 inches from top of pipe.
   e. Non-pressure Piping (high-pop spray) – 18 inches from top of pipe
   f. Non-pressure Piping (high-pop rotor) - 24 inches from top of pipe.
   g. Control Wiring/Communication Cable - Side of pressure main or at 18 inch depth if installed in a separate trench with no mainline piping.
   h. Drip Tubing - 12 inches from top of pipe.
   i. Emitter Tubing (Micro-tubing) - 8 inches from top of pipe.

3. Boring will be permitted only where pipe must pass under obstruction(s) which cannot be removed. In backfilling bore, final density of backfill shall match that of surrounding soil. It is acceptable to use sleeves of suitable diameter installed first by jacking or boring, and pipe laid through sleeves. Observe same precautions as though pipe were installed in open trench.

4. Vibratory Plow - Non-pressure piping may be installed through use of vibratory plow method if consultant determines soil conditions are satisfactory for this method of installation. Vibratory plowing does not relieve installer of minimum pipe depths.

D. Pressure Supply Piping Locating Tape for Non-Potable Systems: Markline Tape, 3” wide detectable tape, NP purple in color with the words "CAUTION: RECYCLED/ RECLAIMED WATERLINE BELOW" printed every 36 inches. Place 12” below finish grade.

2.06 INSTALLATION - Locate other equipment as near as possible to locations designated. Consultant shall review deviations prior to installation.

A. PVC Piping - Snake pipe in trench as much as possible to allow for expansion and contraction. Do not install pipe when air temperature is below 40 degrees F. Place manual drain valves at low points and dead ends of pressure supply piping to insure complete drainage of system. When pipe installation is not in progress, or at end of each day, close pipe ends with tight plug or cap. Perform Work in accordance with good practices prevailing in piping trades.

1. Solvent Weld PVC Pipe - Lay pipe and make all plastic to plastic joints in accordance with manufacturer's recommendations.

2. HDPE Piping - Snake pipe in trench as much as possible to allow for expansion and contraction. Do not install pipe when air temperature is below 40 degrees F. Place manual drain valves at low points and dead ends of pressure supply piping to insure complete drainage of system. When pipe installation is not in progress, or at end of each day, close pipe ends with tight plug or cap. Perform Work in accordance with good practices prevailing in piping trades.

a. Lay pipe and make all plastic to plastic, fusion joints in accordance with manufacturer's recommendations.
b. Fusion: Sections of polyethylene pipe should be joined into continuous lengths on the jobsite above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe supplier's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe supplier. The butt fusion joining will produce a joint weld strength equal to or greater than the tensile strength of the pipe itself. All field welds shall be made with fusion equipment equipped with a Data Logger. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the Quality Control records.

c. Transition fittings shall be used for transition to other pipe materials (1/2" – 4") and utilize butt fusion.

d. Mechanical joining will be used where the butt fusion method cannot be used. Mechanical joining will be accomplished by using a HDPE flange adapter with a Ductile Iron back-up ring.

e. Hot gas fusion, threading, solvents, and epoxies will not be used to join HDPE pipe.

3. Gasketed End Pipes with Joint Restraint System:
   a. Lay pipe and make pipe-to-fitting or pipe-to-pipe joint, following the manufacturer's recommendations. Install joint restraint fittings and pipe restraints on all fittings and adjacent pipe runs per manufacturer's recommendations and as shown on plans.
   b. Prior to backfilling any joint restraints, the Project Manager shall be present to verify that the restraints were installed in the proper locations and that all bolts have been tightened to the manufacturer’s recommendations. Any restraints that are buried prior to inspections shall be excavated to allow for review and inspection prior to approval.


B. Drip Tubing:
   1. Make all fitting connections as per manufacturer's recommendations.
   2. Use only manufacturer provided or recommended hole punch when making penetrations in drip tubing for insert fittings. Use of any other hole punch shall be cause for immediate removal and replacement of all installed drip tubing.
   3. Install drip line blow-out stubs at all dead ends of drip tubing.

C. Control Wiring:
   1. Low Voltage Wiring:
      a. Install in conduit, as indicated on plans.
      b. Bury control wiring between controller and electric valves in pressure supply line trenches, strung as close as possible to main pipe lines with such wires to be consistently located below and to one side of pipe, or in separate trenches.
      c. Bundle all 24 volt wires at 10 foot intervals and lay with pressure supply line pipe to one side of the trench.
      d. Provide an expansion loop at every pressure pipe angle fitting, every electric control valve location (in valve box), and every 500 feet. Form expansion loop by wrapping wire at least 8 times around a 3/4 inch pipe and withdrawing pipe.
      e. Make all splices and E.C.V. connections using 3M DBY, King 600 DBY/R direct bury connectors, or similar dry splice method.
      f. Install all control wire splices not occurring at control valve in a separate splice valve box.
      g. Install one control wire for each control valve.
      h. Maintenance spare wires - In addition to spare wires labeled on drawings, extend two spare #14 AWG UFUL control wires and one spare #14 AWG UFUL common wire from controller pedestal to the end of each and every leg of mainline. Label maintenance spare wires at controller and wire stub box.
   2. Low Voltage Wiring– 2-Wire:
      a. Bury control wiring between controller and electric valves in pressure supply line trenches, strung as close as possible to main pipe lines with such wires to be consistently located below and to one side of pipe, or in separate trenches.
      b. Provide an expansion loop at every pressure pipe angle fitting, every electric control valve location (in valve box), and every 500 feet. Minimum 5 feet in every valve box, 2 feet at every angle fitting and 10 feet at every future phase line.
      c. Make all splices and E.C.V. connections using 3M DBY-6, King 600 DBR/Y connectors, or similar dry splice method.
      d. Install all control wire splices not occurring at control valve in a separate splice valve box.
e. Install one decoder for each control valve or as indicated on plans.
f. The wire paths shall be sized per distance requirements or as shown on plans. The two wire decoder cable shall be of the type indicated on the plans or per manufacturer recommendation.
g. The two-wire paths may be spliced, or “teed”, permitting extensions of the path in multiple directions. In general, the distance from the controller to the end of any one end of a “tee” or wire run shall not exceed the maximum for the gauge of wire, even if the total of all wire exceeds that number. All wire splices must be made in a valve box with DBR-6 or equal direct-burial waterproof connectors.
h. Grounding of decoders and decoder wire shall occur every 500' of wire or every 8TH decoder and at all ends of 2-wire decoder cable run.
i. Grounding shall occur at right angles to wire path and shall have an impedance of 10 Ohms or less, or shall meet the standards of the Earth Grounding Guidelines by ASIC.
j. Where limits of work consist of narrow areas that make grounding rods installed at right angles a hardship, contractor shall utilize grounding plates installed at a minimum distance of 4’ offset and parallel to wire path. Avoid installing grounding near other electrical equipment.

3. High Voltage Wiring for Automatic Controller:
   a. Provide 120 volt power connection to automatic controller by contractor.
   b. All electric work shall conform to local codes, ordinances, and authorities having jurisdiction. All high voltage electrical work shall be performed by licensed electrician.

D. Automatic Controller:
   1. Install controller in accordance with manufacturer’s instructions as detailed and where shown on Drawings.
   2. Connect remote control valves to controller in numerical sequence as shown on Drawings.
   3. Owner shall approve final location of controller prior to installation.
   4. Each controller shall have a dedicated separate ground wire and grounding rod as detailed. Earth grounding shall be connected via a factory supplied copper ground lug inside the controller, for connection to earth ground hardware via 6 AWG(4mm dia.) copper wire (see ASIC Earth Grounding Guideline 100-2002 for details of earth grounding irrigation control systems available online at www.asic.org). Ground wire shall be extended underground, at right angles to any communications wiring, to approved direct burial earth grounding hardware at least 6 ft./2m from the controller location. Earth Ground shall be have an impedance of 10 Ohms or less, or shall meet the standards of the Earth Grounding Guideline cited above.
   5. Connect remote control valves to controller in numerical sequence as shown on Drawings.
   6. All above ground conduit shall be rigid galvanized with appropriate fittings. All below ground conduit shall be schedule 40 PVC.

E. Electric Control Valves - Install cross-handle four inches below finished grade where shown on Drawings as detailed. When grouped together, allow minimum of 12 inches between valve box sides. Install each remote control valve in a separate valve box. Install valve box flush with grade or when present flush with surfacing material (rock mulch). When parallel to roadway, sidewalk or other permanent element or structure, control valve and box to be installed perpendicular to element or structure, spaced equally.
   1. All connections in the two-wire paths (outside the controller enclosure) shall be made with 3M DBR-6 waterproof, strain-relieving direct burial connectors, or exact equals. Decoder output to solenoid connections shall be made with 3M DBY waterproof, strain-relieving connectors, or exact equals. No substitution of wire or wire connector specifications is permissible. All connections, tees, and splices shall be positioned in valve boxes for future location and service.
   2. The installer shall provide adequate earth ground (not to exceed 10 Ohms, or in compliance with practices as defined in American Society of Irrigation Consultants Earth Grounding Guideline 100-2002, available at www.asic.org) and connect it to one of the decoder ground 500’, of wire or every 8TH decoder, whichever is shorter. Minimum ground hardware shall be a 4” x 36” (100 x 915mm) copper plate with at least 10AWG/2.5mm dia. copper wire. In high lightning areas, grounding may be increased to every 500 ft./150m or 10 decoders.
   3. Ground connections from decoder ground lead to grounding hardware shall be made by joining the 12AWG (2mm dia.) decoder ground wire with a 10AWG (2.5mm dia.) solid copper lead in an approved wire nut of appropriate size, inserted in a DBR-6 waterproof direct burial connector, or with an approved wire clamp. Ground hardware shall extend at right angles from the two-wire path, and ground hardware shall be located at least 8ft./2m away from the two-wire path.
4. Where limits of work consist of narrow areas that make grounding rods installed at right angles a hardship, contractor shall utilize grounding plates installed at a minimum distance of 4' offset and parallel to wire path. Avoid installing grounding near other electrical equipment.

F. Quick Coupling Valves - Install quick couplers on swing-joint assemblies as indicated on construction details; plumb and flush to grade. Angled nipple relative to pressure supply line shall be no more than 45 degrees and no less than 10 degrees.

G. Drip and Sub-Surface Valve Assemblies - Install valve assembly as detailed.

H. Drip Emitters - Stake all surface emitters as detailed and staked with acceptable tubing stakes.

I. Drain Valves - Install one manual drain valve on pressure supply line directly downstream of backflow preventer and at all low points in pressure supply line as detailed. Provide a three cubic foot drainage sump for drain valve as detailed.

J. Valve Boxes:
   1. Install one valve box for each type of valve installed as detailed. Valve box extensions are not acceptable except for master valves and flow sensors. Install gravel sump after compaction of all trenches. Place final portion of gravel inside valve box after valve box is backfilled and compacted.
   2. Brand controller letter and station number on lid of each valve box. Letter and number size shall be no smaller than 1 inch and no greater in size than 1 1/2 inches. Depth of branding shall be no more than 1/8 inch into valve box lid.
   3. Concrete polymer boxes shall be labeled with branded inserts per manufacturer's recommendations.

K. Sprinkler Valves - Install where shown on Drawings as detailed.

L. Sprinkler Heads - Install sprinkler heads where designated on Drawings or where staked. Set to finish as detailed. Spacing of heads shall not exceed the maximum indicated on Drawing unless re-staked as directed by Consultant. In no case shall the spacing exceed maximum recommended by manufacturer. Install heads on swing joints or riser assemblies as detailed. Adjust part circle heads for proper coverage. Adjust heads to correct height after sod is installed. Plant placement shall not interfere with intended sprinkler head coverage, piping, or other equipment. Consultant may request nozzle changes or adjustments without additional cost to the Owner.

M. Backflow Preventer - Install as detailed at location designated on Drawings.

N. System Pump - Size and type required for project. Installed per manufacturers recommendations and as detailed.

O. Master Valve – Install as detailed at location designated on Drawings.

P. Flow Sensor - Install as detailed at location designated on Drawings.

Q. Backfilling - Do not begin backfilling operations until required system tests have been completed. Backfill shall not be done in freezing weather except with review by Consultant. Leave trenches slightly mounded to allow for settlement after backfilling is completed. Trenches shall be finish graded prior to walk-through of system by Consultant.
   1. Materials - Excavated material is generally considered satisfactory for backfill purposes. Backfill material shall be free of rubbish, vegetable matter, frozen materials, and stones larger than 1 inch in maximum dimension. Do not mix subsoil with topsoil. Material not suitable for backfill shall be hauled away. Contractor shall be responsible for providing suitable backfill if excavated material is unacceptable or not sufficient to meet backfill, compaction, and final grade requirements.
   2. Do not leave trenches open for a period of more than 48 hours. Open excavations shall be protected in accordance with OSHA regulations.
   3. Compact backfill to 90% maximum density, determined in accordance with ASTM D155-7 utilizing the following methods:
      a. Mechanical tamping.
      b. Puddling or ponding. Puddling or ponding and/or jetting is prohibited within 20'-0" of building or foundation walls.

R. Piping Under Paving:
1. Provide for a minimum cover of 18 inches between the top of the pipe and the bottom of the aggregate base for all pressure and non-pressure piping installed under asphaltic concrete or concrete paving.

2. Piping located under areas where asphalt or concrete paving will be installed shall be bedded with sand (a layer 6" below pipe and 6" above pipe).

3. Compact backfill material in 6" lifts at 90% maximum density determined in accordance with ASTM D1557 using manual or mechanical tamping devices.

4. Set in place, cap, and pressure test all piping under paving, in presence of Owner prior to backfilling and paving operations.

5. Piping under existing walks or concrete pavement shall be done by jacking, boring, or hydraulic driving, but where cutting or breaking of walks and/or concrete is necessary, it shall be done and replaced at no cost to Owner. Obtain permission to cut or break walks and/or concrete from Owner.

S. Water Supply and Point of Connection - Water supply shall be extended as shown from water supply lines.

2.07 FIELD QUALITY CONTROL:

A. Flushing - After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads, quick coupler assemblies, and hose valves, thoroughly flush piping system under full head of water pressure from dead end fittings. Maintain flushing for 5 minutes through furthest valves. Cap risers after flushing.

B. Pressure Testing - Conduct test in presence of Consultant. Arrange for presence of Consultant 48 hours in advance of testing. Supply force pump and all other test equipment. Compressed air shall not be used for pressure testing system.

1. After backfilling, and installation of all control valves, fill pressure supply line with water, and pressurize to 40 PSI over the designated static pressure or 120 PSI, whichever is greater, for a period of 2 hours.

2. Leakage, Pressure Loss - Test is acceptable if no loss of pressure is evident during the test period.

3. Leaks - Detect and repair leaks.

4. Retest system until test pressure can be maintained for duration of test.

5. Before final acceptance, pressure supply line shall remain under pressure for a period of 48 hours.

6. Pressure test shall be scheduled and passed prior to scheduling of Substantial Completion Walk-through.

C. Walk-Through for Substantial Completion:

1. Arrange for Consultant's presence 48 hours in advance of walk-through.

2. Entire system shall be completely installed and operational prior to scheduling of walk-through.

3. Operate each zone in its entirety for Consultant at time of walk-through and additionally, open all valve boxes if directed.

4. Generate a list of items to be corrected prior to Final Completion.

5. Furnish all materials and perform all work required to correct all inadequacies of coverage due to deviations from Contract Documents.

6. During walk-through, expose all drip emitters under operations for observation by Consultant to demonstrate that they are performing and installed as designed, prior to placing of all mulch material. Schedule separate walk-through if necessary.

7. Supply Consultant with prints of irrigation as-builts prior to scheduling substantial completion walk-through.

D. Walk-Through for Final Completion:

1. Arrange for Consultant’s presence 48 hours in advance of walk-through.

2. Show evidence to Consultant that Owner has received all accessories, charts, record drawings, and equipment as required before Final Completion walk-through is scheduled.

3. Operate each zone, in its entirety for Consultant at time of walk-through to insure correction of all incomplete items.

4. Items deemed not acceptable by Consultant shall be reworked to complete satisfaction of Consultant.

5. If after request to Consultant for walk-through for Final Completion of irrigation system, Consultant finds items during walk-through which have not been properly adjusted, reworked, or replaced as indicated on list of incomplete items from previous walk-through, Contractor shall be charged for all subsequent walk-throughs. Funds will be withheld from final payment and/or retainage to Contractor,
in amount equal to additional time and expenses required by Consultant to conduct and document further walk-throughs as deemed necessary to insure compliance with Contract Documents.

6.

2.08 ADJUSTING - Upon completion of installation, fine-tune entire system by adjusting patterns and break-up pins, and setting pressure reducing valves at proper and similar pressure to provide optimum and efficient coverage. Flush and adjust all sprinkler heads for optimum performance and to prevent overspray onto walks, roadways, and buildings as much as possible. Heads of same type shall be operating at same pressure +/- 10%.

A. If it is determined that irrigation adjustments will provide proper coverage, and improved water distribution as determined by Consultant, contractor shall make such adjustments prior to Final Acceptance, as directed, at no additional cost to Owner. Adjustments may also include changes in nozzle sizes, degrees of arc, and control valve throttling.

B. All sprinkler heads shall be set perpendicular to finish grade unless otherwise noted on Construction Plans or directed by Consultant.

C. Areas which do not conform to designated operation requirements due to unauthorized changes or poor installation practices shall be immediately corrected at no additional cost to the Owner.

2.09 CLEANING - Maintain continuous cleaning operation throughout duration of work. Dispose of, off-site at no additional cost to Owner, all trash or debris generated by installation of irrigation system.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. RELATED DOCUMENTS: The General Contract Conditions, Drawings and other Division 1 Specification sections apply to Work of this section.

B. DESCRIPTION: The work of this section consists of ripping, fertilizing, soil conditioning and fine grading of topsoil in preparation for seeding, sodding or planting operations.

C. RELATED SECTIONS:

1. Earthwork - Section 310000
2. Sodding - Section 329223
3. Planting- Section 329300

1.2 SUBMITTALS:

A. Quality Control Submittals:

1. Existing Soil Testing: Contractor shall be responsible for providing and paying for three (3) soil tests from three (3) locations (to be determined in-field by Owner's Representative and Contractor) prior to any soil preparation work is to begin. Test results shall be provided to Owner's Representative as per Section 01 40 00. Costs to be calculated into seeding and soil preparation costs.

2. Certificates: State, federal and other inspection certificates shall accompany invoice for materials showing source or origin. Submit to Owner's Representative prior to acceptance of material.

3. Material Analysis: Provide soil conditioner analysis performed no more than 3 months prior to delivery to site. Submit 0.5 cubic foot sample of soil conditioner at least 14 days prior to delivery to the site.

1.3 DELIVERY, STORAGE AND HANDLING:

A. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened containers bearing manufacturer's guaranteed chemical analysis, name, trade name, trademark and conformance to state law, bearing name and warranty or producer. If fertilizers are delivered in bulk, supplier shall provide the same certification as above.

B. Notify the Owner's Representative of delivery schedule in advance so material can be inspected upon arrival at project site. Immediately remove unacceptable material from project site.

1.4 PROJECT/SITE CONDITIONS:

A. General: Do not perform work when climate and existing site conditions will not provide satisfactory results.
B. Vehicular accessibility on site shall be as directed by the Owner’s Representative. Repair damage to prepared ground and surface caused by vehicular movement during work under this section to original condition at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 SOIL MATERIALS:

A. Soil Conditioner:

1. Composted material meeting the following requirements – shall be adjusted accordingly dependent upon Contractor’s soil test results (at no additional cost):
   a. Organic matter: 25% minimum
   b. Salt content: 4.0 mmhos/cm maximum
   c. pH: 8.5 maximum
   d. Carbon to nitrogen ratio of 10:1 to 25:1
   e. No live noxious weed seeds or plants shall be present

2. Mountain peat, aspen humus, gypsum, manure and sand will not be accepted.

2.2 OTHER MATERIALS:

A. Fertilizer: Diamonium phosphate (18-46-0). Shall be adjusted accordingly dependent upon Contractor’s soil test results (at no additional cost).

B. Post Emergent Herbicide: Roundup (Glyphosate) as manufactured by Monsanto Company or approved equal.

C. Sand: Washed local sand with no deleterious materials.

PART 3 EXECUTION

3.1 EXAMINATION:

A. General: Verify that existing site conditions are as specified and satisfactory to perform the work in this section. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the installer. Starting installation constitutes acceptance of site conditions.

   1. Grades: Inspect to verify rough grading is within +/- 0.1 foot of grades indicated and specified.
   2. Damaged Earth: Inspect to verify that earth rendered unfit to receive planting due to concrete, water, mortar, limewater or any other contaminant dumped on it has been removed and replaced with clean earth from a source approved by the Owner’s Representative.

B. Unsatisfactory Conditions: Report in writing to General Contractor with copy to Owner’s Representative.

C. Acceptance: Beginning of installation means acceptance of existing conditions by installer.

3.2 PREPARATION

A. Protection
1. Locate sewer, water, irrigation, gas, electric, phone and other pipelines or conduits and equipment prior to commencing work.
2. Be responsible for proper repair to landscape, utilities, walls, pavements and other site improvements damaged by operations under this section.

B. Weed Control: Remove annual weeds by tilling. Remove perennial weeds by applying herbicide 1 week before soil preparation and as needed, but no sooner than 3 months before beginning work.

C. Surface Grade: Remove weeds, debris, clods and rocks larger than $\frac{1}{2}$". Dispose of accumulated debris at direction of Owner’s Representative.

D. Runoff: Take measures and furnish equipment and labor necessary to control the flow, drainage, and accumulation of water. Insure that all water will run off the grades.

E. Erosion Control: Take measures and furnish equipment and labor necessary to control and prevent soil erosion, blowing soil and accumulation of wind-deposited material on the site throughout duration of work.

3.3 INSTALLATION

A. Fine Grading in all Landscape Areas:

1. Do fine grading for all areas prior to seeding or planting.
2. For ground surface areas surrounding buildings to be landscaped, maintain required positive drainage away from buildings.
3. Establish finish grades to within 0.1 foot of grades indicated. Allow 1-1/2 inch for thickness of sod.
4. Finished grades of shrub, ground cover beds and planter pots shall be 4" below top of adjacent pavement, or cap, for thickness of mulch, unless otherwise specified on drawings.
5. Noxious weeds or parts thereof shall not be present in the surface grade prior to seeding.
6. Prior to acceptance of grades, hand rake to smooth, even surface, free of debris, clods, rocks and vegetable matter greater than 0.5 inch.

3.4 NOTIFICATION AND INSPECTION

A. Inspection: Provide notice to Owner’s Representative requesting inspection at least seven (7) days prior to anticipated date of completion.

B. Deficiencies: Owner’s Representative will specify deficiencies to Contractor who shall make satisfactory adjustments and shall again notify Owner’s Representative for final inspection.

3.5 CLEANING

A. General: Remove debris and excess materials from site. Clean out drainage inlet structures. Clean paved and finished surfaces soiled as a result of work under this Section, in accordance with direction given by Owner’s Representative.

3.6 PROTECTION

A. General: Provide and install barriers as required and as directed by Owner’s Representative to protect completed areas against damage from pedestrian and vehicular traffic until acceptance by Owner. Contractor is not responsible for malicious destruction caused by others.

END OF SECTION
1.1 SUMMARY

A. RELATED DOCUMENTS
   1. The General Contract Conditions, Drawings and other Division - 1 Specification sections apply to Work of this section.

B. DESCRIPTION
   1. The work of this section consists of furnishing, stockpiling and placing topsoil on a previously prepared subgrade.

C. RELATED WORK
   1. Soil Preparation - Section 329113
   2. Sodding – Section 329223
   3. Planting- Section 329300

1.2 QUALITY ASSURANCE

A. Contractor shall submit soil analysis report for on-site topsoil from the State University Agricultural Extension Service or other approved soil testing laboratory. Report shall cover soil textural classification (percentages of sand, silt, and clay), pH and include additive recommendations. Testing will be at the expense of the Contractor. Contractor to amend topsoil per test recommendations with approval of Owner’s Representative.

1.3 DELIVERY, STORAGE AND HANDLING

A. Do not deliver or place topsoil in frozen, wet, or muddy condition.

PART 2 PRODUCTS

2.1 ON-SITE TOPSOIL

A. On-site Topsoil shall consist of loose friable loam free of subsoil, trash, stumps, roots, rocks, heavy clay or hard clods greater than 1” in size, toxic substances, brush, weed seeds and reproductive vegetative plant parts (such as Knapweed, Purple Loosestrife, and Canadian Thistle) and other material which would be deleterious to its use on the project. Strip from top 6” of existing topsoil where organic material is visible and as directed by the Project Manager. Verify depth and size of topsoil stockpile with Project Manager.
2.2 IMPORTED TOPSOIL

A. All topsoil shall be a loam or sandy loam. At least 10 days prior to topsoil delivery, notify Owner’s Representative of the source(s) from which topsoil is to be furnished. Topsoil shall be furnished by the Contractor and shall be a natural, friable soil representative of productive soils in the vicinity. It shall be obtained from the top 6" of well drained areas.

B. Fertile, friable, loamy soil, reasonably free from subsoil, refuse, roots, heavy or stiff clay, stones larger than 1 inch, coarse sand, noxious seeds, sticks, brush, litter, and other deleterious substances; suitable for the germination of seeds and the support of vegetative growth. The pH value shall be between 7.0 and 8.0 and the total salts maximum content shall be 3 MMHOS/CM.

C. Soil Texture: Sand, 30 to 50 percent; silt, 30 to 50 percent; clay, 5 to 30 percent.

D. Additives: As determined by soil fertility tests.

E. % Organic Content: 2.9% minimum.

PART 3 EXECUTION

3.1 STOCKPILING

A. Stockpile topsoil within boundaries of staging areas within Limits of Construction as shown on drawings or as directed by the Project Manager. Topsoil stockpiles shall be separate from other soil and materials piles and protected with silt fence on the down-gradient side of the stockpile. Contractor shall construct storage piles to freely drain surface water. Seed or cover storage piles to prevent erosion.

3.2 PLACING TOPSOIL

A. Scarify compacted subgrade to a 6-inch depth to bond topsoil to subsoil. Place topsoil to a minimum depth of 4-inches after settlement. Topsoil shall be free from weeds, sod, clods and stones larger than 1-inch, toxic substances, litter or other deleterious material. Spread evenly and grade to elevations and slopes shown. Hand rake areas inaccessible to machine grading.

B. Utilize salvaged topsoil as the top layer to the extent available.

END OF SECTION
SECTION 32 9220
NATIVE SEEDING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes requirements for the installation of native seed, mulch, erosion control material (if applicable), and maintenance of the seeded areas, to be achieved as outlined in the “Maintenance” section below.

B. Related Sections:
   1. Division 01 Section “Erosion and Sedimentation Control”.
   2. Division 01 Section “Tree Retention and Protection”.
   3. Division 31 Section “Earth Moving”.
   4. Division 31 Section “Watering”.
   5. Division 32 Section “Irrigation System”.
   6. Division 32 Section “Soil Preparation”.
   7. Division 32 Section “Topsoil”.
   8. Division 32 Section “Trees, Plants, and Groundcovers”.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, herbicide, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

F. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

G. Weeds: Including but not limited to Puncturevine, Field Bindweed, Twitch, Dandelion, Jimsonweed, Diffuse, Spotted and Russian Napweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Prickly Lettuce, Lambsquarter, Chickweed, Cress, Crabgrass, Canada Thistle, Nutgrass, Blackberry, Tansy Ragwort, Bermuda Grass, Johnsongrass, Poison Ivy, Nut Sedge, Nimble Weed, Bent Grass, Garlic Mustard, Perennial Sorrel, and Broom Grass or any weed listed on Colorado Noxious Weed List and Watch List.
1.4 REFERENCES

A. Comply with U.S. Department of Agriculture Rules and Regulations under the Federal Seed Act and be equal to or better in quality than the standards for Certified Seed.

B. Colorado Department of Transportation (CDOT) – Standards Specifications for Road and Bridge Construction.

1.5 SUBMITTALS

A. See Division 01 Section “Submittals” for submittal requirements.

B. Materials: The Contractor shall submit to the Project Manager for approval a complete list of all materials to be used during this portion of the work prior to delivery of any materials to the site. Include complete data on source, amount and quality. This submittal shall in no way be construed as permitting substitution for specific items described on the plans or in these specifications unless approved in writing by the Project Manager.
   1. Certification of Seed: From seed vendor for each seed mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
   2. Native Grass Species (supplied as pure live seed): Submit lab germination test results for all grass species. Submit an affidavit that describes estimated purity for all forb species that are not typically tested.
   3. Pesticides: Include product label and manufacturer’s application instructions specific to this Project.
   4. Product Certificates: For soil amendments and fertilizers, from manufacturer.

C. Qualification Data: For qualified landscape Installer.

D. Material Test Reports: For existing in-place surface soil.
   1. Soil Analysis: See Division 32 Section “Soil Preparation”
   2. Analysis for each soil amendment.
   3. Analysis for each amended planting soil.

E. Analysis and standards: Wherever applicable, for non-packaged materials, provide two copies of analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

F. Seeding schedule: Submit, in writing, two (2) copies of proposed seeding schedule, indicating dates for site preparation, seeding, mulching, erosion control, and coordination with plant procurement, planting soil preparation, plant delivery and planting. Schedule all Work during specified planting seasons. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.

G. Maintenance Instructions: Recommended procedures for maintenance of non-irrigated native seed areas during a calendar year. Submit before expiration of required initial maintenance periods.

H. Contract Closeout Submittals:
   1. Operating and Maintenance Data: At completion of work, submit one (1) digital copy and two (2) hard copies to the Project Manager in accordance with Division 01 Section “Contract Closeout”. Include directions for irrigation, aeration, mowing, fertilizing, and spraying as required for continued and proper maintenance through full growing season and dormant period.
   2. Warranty for Native Seed Areas: At completion of work, furnish written warranty to City Project Manager based upon specified requirements.

I. The Project Manager reserves the right to reject the seed at any time prior to acceptance and that fails to meet specification requirements. Promptly remove rejected seed from the site.
1.6 QUALITY CONTROL

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful native grass establishment.
   1. Experience: Five years' experience in native seed installation in addition to requirements in Division 01 Section "Quality Control".
   2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   3. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Pre-installation Conference: Conduct conference at Project site to coordinate the process with other trades, to coordinate equipment movement within planting areas and to avoid soil compaction, to review proposed methods of installation, performance criteria, and maintenance procedures. Review underground utility location maps and plans. This meeting shall be coordinated by the Contractor, and comply with requirements in Division 01.

C. Standards: All materials and methods used during this portion of the work shall meet or exceed applicable federal, state, county, and local laws and regulations. All seed shall be free from insects and disease. Species shall be true to their scientific name as specified.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed: Shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net weight, origin, the percent of weed seed content, the guaranteed percentage of purity and germination, pounds of pure live seed (PLS) of each seed species, and the total pounds of PLS in the container. Seed that has become wet, moldy or damaged in transit or in storage will not be acceptable.

B. Other Packaged Materials: Deliver packaged materials in original unopened containers bearing weight, analysis and name of supplier.

C. Fertilizer: Deliver organic or chemical fertilizer to site in original unopened container bearing manufacturer's guaranteed chemical analysis, name, trade name, trademark and conformance to state law, and bearing name and warranty of producer.

D. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
   4. Seed: Deliver seed materials in original unopened containers, showing bearing weight, analysis and name of supplier.
   5. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer's guaranteed chemical analysis, name, trade name, trademark and conformance to state law, and bearing name and warranty of producer.

E. Material will be inspected upon arrival at project site. Project Manager will reject any opened or unacceptable materials as described above. Store all materials in a manner to prevent wetting and deterioration.

F. Immediately remove unacceptable material from job site.
1.8 PROJECT/SITE CONDITIONS

A. Work scheduling: Proceed with and complete landscape work rapidly, as portions of the site become available, working within the specified planting season and approved schedule.

B. Planting Restrictions: Planting is preferred in fall and winter months but may be performed during one of the periods noted below. Variance from the schedule shall be permitted only with written approval from the Project Manager. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

C. Vehicular accessibility on site shall be as directed by Project Manager. Repair damage to prepared topsoil and existing surfaces, caused by vehicular access and movement during work under this section, to original condition at no additional cost to the City.

D. Do not drill or sow seed during windy, rainy weather or when ground is frozen or otherwise unable to be tilled.

E. Seeding Season: Seeding shall generally occur during the specified windows below. Seeding dates may be modified when temperature and moisture conditions are favorable. Verify with local producers and contractors prior to finalizing.

<table>
<thead>
<tr>
<th>Seed Type</th>
<th>Non-Irrigated Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Grasses</td>
<td>November 15-April 15</td>
</tr>
</tbody>
</table>

1. Dormant Seeding: Upon approval of the Project Manager, dormant seeding for Non-irrigated areas may be accomplished between November 15 and April 15. No seeding shall be done when the ground is frozen, muddy, covered with snow, or otherwise in a condition unsuitable for seeding. Dormant seeding will not relieve the Contractor from the warranty or the acceptance requirements specified elsewhere in this specification.

F. Existing conditions:
1. Existing Plants: Install sod only after all other landscape and irrigation items have been installed and accepted by the Project Manager.
2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Project Manager before planting.
4. If weeds are present on site, treat with pesticide prior to preparing soil for installing seed or sod as specified below.

G. Coordination:
1. Coordinate with construction of utilities on site. Do not begin placing topsoil until underground work is completed in the area.
2. Coordinate with seeding and landscape Contractor(s) approved schedule. Limit construction access to areas where topsoil has been placed if placement is completed more than three (3) days prior to commencement of landscaping in the area. Limit fine grading to areas that can be prepared for planting within twenty-four (24) hours after fine grading.
3. Coordinate with Contractors work requiring access to site over seeded areas.
4. Coordinate with installation of underground irrigation system.
PART 2 PRODUCTS

1.9 MATERIALS

A. Topsoil: See Division 32 Section “Topsoil”.

B. General:
   1. The selected seed mix must be approved by the Town Project Manager and the Project Landscape Architect or Ecologist prior to its incorporation into the project.
   2. All seed brands shall be free from Colorado prohibited noxious weed seeds, including but not limited to Canada Thistle, Field Bindweed, Johnsongrass, and Leafy Spurge. The Contractor shall furnish to the Project Manager a signed statement certifying that the seed is from a lot that has been tested by a recognized laboratory for seed testing within six months prior to the date of delivery.
   3. Computation for quantity of seed required on the project is based on Pure Live Seed (PLS).
   4. The formula used for determining the quantity of PLS shall be:
      \[
      \text{Pounds of Seed} \times (\text{Purity} \times \text{Germination}) = \text{Pounds of PLS}.
      \]
   5. If seed available on the market does not meet the minimum purity and germination specified, the Contractor must compensate for a lesser percentage of purity or germination by furnishing sufficient additional seed to equal the specified product. Product comparison shall be made on the basis of PLS in pounds, stated on each seed bag.

C. Seed Mixes:
   1. Depression Seed Mix:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Variety*</th>
<th>Common Name</th>
<th>PLS lbs/ac</th>
<th>% by Weight</th>
<th>PLS/sq ft</th>
<th>% of PLS/sq ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graminoids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carex nebrascensis</td>
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<td>Nebraska sedge</td>
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<tr>
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<tr>
<td>Elymus lanceolatus</td>
<td>Sodar</td>
<td>thickspike wheatgrass</td>
<td>2.80</td>
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<tr>
<td>Elymus trachycaulus</td>
<td>Pryor</td>
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<td>2.70</td>
<td>10</td>
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<tr>
<td>Juncus torreyi</td>
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<td>Torrey's rush</td>
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<td>0</td>
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<td>Panicum virgatum</td>
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<td>Arriba</td>
<td>western wheatgrass</td>
<td>4.50</td>
<td>16</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Schizachyrium scoparium</td>
<td>Itasca</td>
<td>little bluestem</td>
<td>2.25</td>
<td>8</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Spartina pectinata</td>
<td>vns.</td>
<td>prairie cordgrass</td>
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<td>6</td>
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<tr>
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<td>0</td>
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Graminoid Totals 20.39 74 122 81
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<tr>
<th>Scientific Name</th>
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<th>Common Name</th>
<th>PLS lbs/ac</th>
<th>% by Weight</th>
<th>PLS/sq ft</th>
<th>% of PLS/sq ft</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graminoids</strong></td>
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<td>sideoats grama</td>
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<tr>
<td>Elymus lanceolatus</td>
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<tr>
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<tr>
<td><strong>Forbs</strong></td>
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<td></td>
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<td></td>
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</tr>
<tr>
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<td>5</td>
</tr>
<tr>
<td>Gaillardia aristata</td>
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<td>1.70</td>
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<td>8</td>
<td>6</td>
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<tr>
<td>Ratibida columnifera</td>
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</tbody>
</table>

* vns. = variety not specified; PLS = pure live seed

Drill Seeded Rate: 19.8 PLS#/Acre
Mechanical Broadcast Rate: 19.8 PLS#/Acre
Hand Broadcast Areas Rate: 39.6 PLS#/Acre

2. Mid Height Seed Mix:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Variety*</th>
<th>Common Name</th>
<th>PLS lbs/ac</th>
<th>% by Weight</th>
<th>PLS/sq ft</th>
<th>% of PLS/sq ft</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graminoids</strong></td>
<td></td>
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<td>Canada wildrye</td>
<td>6.00</td>
<td>18</td>
<td>14</td>
<td>10</td>
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<tr>
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<td>Sodar</td>
<td>thickspike wheatgrass</td>
<td>4.00</td>
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<td>14</td>
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<tr>
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<td>slender wheatgrass</td>
<td>2.40</td>
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<td>7</td>
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<tr>
<td>Pascopyron smithii</td>
<td>Arriba</td>
<td>western wheatgrass</td>
<td>5.00</td>
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<tr>
<td>Schizachyrium scoparium</td>
<td>Itasca</td>
<td>little bluestem</td>
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<tr>
<td>Sporobolus cryptandrus</td>
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<td>sand dropseed</td>
<td>0.05</td>
<td>0</td>
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<tr>
<td><strong>Gramminoid Totals</strong></td>
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<td>32.05</td>
<td>94</td>
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<tr>
<td><strong>Forbs</strong></td>
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<tr>
<td>Achillea millefolium</td>
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<tr>
<td>Artenusua frigida</td>
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<td>fringed sage</td>
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<tr>
<td>Gaillardia aristata</td>
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<td>1.70</td>
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<tr>
<td>Ratibida columnifera</td>
<td>vns.</td>
<td>prairie coneflower</td>
<td>0.25</td>
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<td><strong>Forb Totals</strong></td>
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</table>
3. Low-Grow Mix:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Variety*</th>
<th>Common Name</th>
<th>PLS lbs/ac</th>
<th>% by Weight</th>
<th>PLS/sq ft</th>
<th>% of PLS/sq ft</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graminoids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Bouteloua dactyloides</td>
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<td>inland saltgrass</td>
<td>1.50</td>
<td>7</td>
<td>18</td>
<td>14</td>
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<tr>
<td>Festuca rubra</td>
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<td>Pleuraphis jamesii</td>
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<td>galleta</td>
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* vns. = variety not specified; PLS = pure live seed

Drill Seeded Rate: 8.9 PLS#/Acre
Mechanical Broadcast Rate: 8.9 PLS#/Acre
Hand Broadcast Areas Rate: 17.8 PLS#/Acre

E. Hydromulch: Comply with Section 213 – Mulching of the CDOT Standards and Specifications for Road and Bridge Construction.

F. Tackifier: Comply with Section 213 – Mulching of the CDOT Standards and Specifications for Road and Bridge Construction.

1.10 SUBSTITUTIONS

A. All substitutions shall be submitted to and approved by the Project Manager prior to construction.

PART 3 EXECUTION

1.11 EXAMINATION

A. Examine areas to be seeded for compliance with requirements and other conditions affecting performance.

1. Verify that finished grades are consistent with the slopes and grades indicated on the Contract Drawings. Verify grades are in conformance with Division 31 Section “Earth Moving”. Obtain the Project Manager’s approval of finished grade prior to proceeding with seeding operations.

2. Verify soil prepare of all areas to be seeded is in accordance with the requirements of Division 32 Section “Soil Preparation”. When completed, the soil shall be firmed by float dragging, followed by steel raking, to provide for the proper seeded surface. The seed bed shall be totally free from rock or clay clods over one inch (1”) in diameter.

3. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a seeding area. If contamination is present in soil, remove the soil and contamination as directed by the Project Manager and replace with new soil.
B. Proceed with seeding only after unsatisfactory conditions have been corrected and approved by the Project Manager.

C. Acceptance: Beginning of installation means acceptance of existing conditions by the Contractor.

1.12 PREPARATION

A. Notify the Project Manager at least seven (7) working days prior to start of seeding operations.

B. Protect existing utilities, paving, planting and other facilities from damage caused by seeding operations. Contractor shall repair any damage at no additional cost to the Town.

C. Utilize equipment having low unit pressure ground contact within seeding areas.

D. Limit preparation to areas that can be seeded within twenty-four (24) hours of preparation.

E. Moisten prepared area before seeding if soil is dry. Water thoroughly and allow surface to dry before seeding. Do not create muddy soil.

F. Erosion Control: Take measures and furnish equipment and labor necessary to control and prevent soil erosion, blowing soil and accumulation of wind-deposited materials on the site throughout the duration of work.

1.13 SEEDING

A. Seed within twenty-four (24) hours after preparation of seed bed. Seeding at other times may only be done if approved by the Project Manager.

B. Areas outside Contract Limits disturbed as a result of construction operations shall be restored at Contractor’s expense.

C. Seed shall be uniformly applied at the specified rate, (half in one direction and the other half perpendicular to the first application). Seed shall be installed at a depth between one-quarter inch (1/4”) and one-half inch (1/2”).

D. Seeds shall be placed with 12” spacing when using a drill seeder.

E. Areas that are too small or steep for mechanical seeding may be hand seeded. Seed shall be uniformly applied at the specified rate utilizing a broadcast spreader and then hand raked in to a depth of no more than one-half inch (1/2”), then roll seed bed to ensure proper contact to the soil.

1.14 EROSION CONTROL MATERIALS

A. Review erosion control measures with the Project Manager prior to installation.

1.15 MULCHING

A. Hydromulch and Tackifier Application: Utilize an approved hydromulcher to apply cellulose fiber at a rate of two-thousand (2,000) pounds per acre. Apply tackifier to comply with CDOT Section 213.02 – Mulching. Contractor shall provide verification of application rates in the form of ship tickets.

B. Mulching shall not be installed when surface water is present resulting from rain, melting snow, irrigation, or other causes.

C. Areas not properly mulched, or any damage that may occur during construction is the responsibility of the Contractor and shall be repaired and re-mulched in an acceptable manner at the Contractor’s expense. Mulching removed by wind, rain, or other causes prior to acceptance shall be re-established by the Contractor at their own expense.
D. The seeded area shall be mulched within eight (8) hours of seeding. Areas not mulched within twenty-four (24) hours after seeding must be re-prepped and re-seeded with the specified seed mix at the Contractor’s expense.

E. Contractor shall remove all hydromulch from surface areas not specified for seeding, including but not limited to plant materials, fences, paved areas, signs, mulch beds, irrigation components and all other objects as directed by the Project Manager.

1.16 CLEANING

A. Perform cleaning during installation of the work and upon completion of the work. Remove from all excess materials, debris and equipment from site. Repair any damage resulting from seeding operations.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove non-degradable erosion-control measures after grass establishment period.

1.17 PROTECTION

A. Restrict vehicular and pedestrian traffic from seeded areas until vegetation is established. Erect signs and barriers as required or directed by the Project Manager at no additional cost to the City.

1.18 MAINTENANCE

A. Refer to Landscape Maintenance section 32 97 00

B. If no native seed maintenance is required per the contract, then the native seed warranty is per the Acceptance sub-section. Maintenance of the native seed area is the responsibility of the Contractor until Final Acceptance.

1.19 ACCEPTANCE

A. Substantial Completion shall be granted when the seeded areas have a uniform plant growth establishing over the entire seeded area. Refer to the Contract General Conditions, Title 19 – Substantial Completion of the Work.

B. Final Acceptance will be granted when native seed areas are in a healthy, vigorous growing condition, and for consistency and completion of coverage for a minimum period of one (1) year from date of Substantial Completion or until the Project Manager and Project Landscape Architect and/or Ecologist are satisfied with germination.

C. Non-irrigated native seed areas shall be established when the following criteria are met:
   1. Total vegetation cover in all zones seeded with cover crop shall exceed fifty percent (50%) by aerial cover and twenty-five percent (25%) of all species present shall be native. Native seed shall be free of weeds, foreign grasses, disease and harmful insects.
   2. At any time during the contract period no more than ten percent (10%) by aerial cover of the seeded area should be dominated by aggressive exotic species such as, but not limited to, red clover (Trifolium spp.), white or yellow sweet clover (Melilotus spp.), Canada thistle (Cirsium arvense), tall fescue (Festuca elatior), field bindweed (Convulvulus arvensis) etc.
   3. During the original warranty period, reseed at once with comparable blend/mix, those areas that have failed to achieve a stand of grass or which in the Project Manager’s opinion are unhealthy.
   4. Reseeding will not be allowed in any season considerable unfavorable for seeding by the Project Manager.
   5. Reseed in a manner to achieve quality as originally specified.
END OF SECTION
SECTION 32 9223
SODDING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes requirements for furnishing and installation of bluegrass sod, and maintenance of sodded areas as outlined in Maintenance Section 1.8.B. until Final Acceptance.

B. Related Sections:
   1. Division 01 Section “Erosion and Sedimentation Control”.
   2. Division 31 Section “Earth Moving”.
   3. Division 31 Section “Watering”.
   4. Division 32 Section “Irrigation System”.
   5. Division 32 Section “Automatic Irrigation Controllers”
   6. Division 32 Section “Soil Preparation”.
   7. Division 32 Section “Topsoil”.
   8. Division 32 Section “Trees, Plants, and Groundcovers”.

1.3 DEFINITIONS

A. Finished Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, pesticides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, herbicide, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

F. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

G. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

A. See Division 01 Section “Submittals” for submittal requirements.

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

C. Sod Certificates:
   1. State, Federal and other inspection certificates for sod shall be provided to the Project Manager a minimum of 10 working days prior to anticipated date of sod delivery.
   2. Submit a list of varieties contained in the sod, and include the source and origin for approval by the Project Manager.

D. Analysis and standards: Wherever applicable, for non-packaged materials, provide two copies of analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

E. Planting schedule: Submit in writing two copies of proposed planting schedule, indicating dates for topsoil placing, site preparation, pesticide treatments, soil preparation, sodding, seeding, and coordination with plant procurement, planting soil preparation, plant delivery and planting. Schedule all Work during specified planting seasons. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.

F. Contract Closeout Submittals:
   1. Operating and Maintenance Data: At completion of work, submit one digital copy and two hard copies to the Project Manager in accordance with Division 01 Section “Contract Closeout”. Include directions for irrigation, aeration, mowing, fertilizing and spraying as required for continued and proper maintenance through full growing season and dormant period.
   2. Warranty for Turfgrass Sod Areas: At completion of work, furnish written warranty to Project Manager based upon specified requirements.

1.5 QUALITY CONTROL

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.
   1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
   2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section "Quality Control."
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Sod Producer: Company specializing in sod production and harvesting with minimum five (5) years' experience, and certified by the State of Colorado Department of Agriculture.
   5. Personnel Certifications: Installers shall have certification the following categories from the Professional Landcare Network:
      a. Certified Landscape Technician - Exterior, with installation maintenance irrigation specialty area(s), designated CLT-Exterior.
   6. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: See Division 32 Section “Soil Preparation”.

D. Preinstallation Conference: Conduct conference at Project site to coordinate the process with other trades, to coordinate equipment movement within planting areas and to avoid soil compaction, to review proposed methods of installation, performance criteria, and maintenance procedures. Review
underground utility location maps and plans. This meeting shall be coordinated by the Contractor, and comply with requirements in Division 1.

E. Standards: All materials and methods used during this portion of the work shall meet or exceed applicable federal, state, county, and local laws and regulations. All sod shall be free from insects and disease. Species shall be true to their scientific name as specified.

F. Materials: The Contractor shall submit to the Project Manager for approval a complete list of all materials to be used during this portion of the work prior to delivery of any materials to the site. Include complete data on source, amount and quality. This submittal shall in no way be construed as permitting substitution for specific items described on the plans or in these specifications unless approved in writing by the Project Manager.

G. Source Quality Control:
1. Sod Materials: Subject to inspection and acceptance. The Project Manager reserves the right to reject at any time or place prior to acceptance, any work and sod which in the Project Manager’s opinion fails to meet these specification requirements.
2. Inspection will be made periodically during sodding, at completion and at end of warranty period by the Project Manager. Primarily for quality; however, other requirements are not waived even though visual inspection results in acceptance.
3. Promptly remove rejected sod from site.

H. Sod Standards:
1. Sod shall consist of healthy, thick turf having undergone a program of regular fertilization, mowing and weed control; free of weeds; uniform in green color, leaf texture and density; healthy, vigorous root system; inspected and found free of disease, nematodes, pests and pest larvae by the State Department of Agriculture.
2. Each piece of Sod shall consist of a sandy-loam soil base that will not break, crumble or tear during sod installation.
3. Sod thickness shall be a minimum three quarters inch (3/4”) thick, excluding top growth and thatch.
4. Thatch layer shall not exceed one half inch (1/2”), uncompressed.
5. Sod shall be delivered and installed within twenty four (24) hours of being cut.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver on pallets properly loaded on vehicles with root system protected from exposure to sun, wind, and heat in accordance with standard practice. Sod that has been damaged by poor handling or improper storage is subject to rejection by the Project Manager.
1. Protect from dehydration, contamination, freezing and heating at all times. Keep stored sod moist and under shade or covered with moistened burlap.
2. Do not drop sod rolls from carts, trucks or pallets.
3. Do not deliver more sod than can be installed within twenty four (24) hours.

B. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer’s guaranteed chemical analysis, name, trade name, trademark, warranty and conformance to state law.

C. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
4. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer’s guaranteed chemical analysis, name, trade name, trademark and conformance to state law, and bearing name and warranty of producer.

D. Material will be inspected upon arrival at project site. Project Manager will reject any opened or unacceptable materials as described above.

E. Immediately remove unacceptable material from job site.

1.7 PROJECT/SITE CONDITIONS

A. Work scheduling: Proceed with and complete landscape work as rapidly as portions of the site become available, working within the specified planting season and approved schedule.

B. Vehicular accessibility on site shall be as directed by Project Manager. Repair damage to prepared topsoil and existing surfaces, caused by vehicular access and movement during work under this section, to original condition at no additional cost to the Town.

C. Install sod between April 15 and October 1 or when irrigation is available for twenty one (21) days for sod establishment.

D. Schedule work for periods of favorable weather. Do not install sod on saturated or frozen soil. The Project Manager reserves the right to deny sod installation on days that are deemed to be unfavorable for installation.

E. Existing conditions:
   1. Existing Plants: Install sod only after all other landscape and irrigation items have been installed and accepted by the Project Manager.
   2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
   3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Project Manager before planting.
   4. If weeds are present on site, treat with pesticide prior to preparing soil for installing sod as specified in this or other Sections.

F. Coordination:
   1. Coordinate with construction of utilities on site. Do not begin placing topsoil and sod until underground work is completed in the area.
   2. Coordinate sodding with Contractor(s) approved schedule. Limit construction access to areas where topsoil has been placed if placement is completed more than 3 days prior to commencement of landscaping in the area. Limit fine grading to areas that can be prepared for planting within twenty four (24) hours after fine grading.
   3. Coordinate with Contractors work requiring access to site over sodded areas.
   4. Coordinate with installation of underground irrigation system.

1.8 WARRANTY

A. Warrant sod areas to be in a healthy, vigorous growing condition, and for consistency and completion of coverage for a period of one (1) year from date of Substantial Completion as a full stand of grass. Re-sod any areas where sod has failed due to disease or other inadequate installation, as defined in this Section.
   1. During the original warranty period, immediately replace the sod with a comparable sod blend/mix in the areas that have failed to achieve a stand of grass or which are unhealthy in the Project Manager’s opinion.
   2. Re-sodding will not be allowed in any season considerable unfavorable for sod installation by the Project Manager.
PART 2 PRODUCTS

2.1 MATERIALS

A. Topsoil: See Division 32 Section “Topsoil”.

B. Soil Preparation: See Division 32 Section “Soil Preparation.”

C. Sod:
   1. Colorado grown Kentucky Bluegrass blend having a healthy, vigorous root system. Blend shall contain a minimum of three (3) improved varieties, of which at least one variety is an aggressive type.
   2. Sod to be produced in accordance with requirements in "Specifications for Turfgrass Sod Materials” and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding."
   3. Harvesting: Sod shall be fertilized 2–3 weeks prior to harvesting. Mow sod to a height of one and one-half inches (1-1/2”) before the sod is lifted. Sod shall be harvested in rolls, and shall not be cut more than 24 hours prior to planting.
   4. Size: Machine cut to a minimum pad thickness of three quarters inch (3/4), excluding top growth and thatch. Provide sod of uniform pad sizes eighteen inches (18”) maximum width by twenty four (24”) minimum length, with maximum five percent (5%) deviation in either length or width. Broken pads or pads with uneven ends will not be acceptable. Sod pads incapable of supporting their own weight when suspended vertically from upper ten percent (10%) of pad will be rejected. Sod which has dried out, sod with adhering soil which breaks, tears, or crumbles away will not be accepted. Sod cut for more than twenty-four (24) hours will not be accepted.
   5. Plastic netting: Sod to be free of plastic netting used during establishment by sod grower.

D. Fertilizer: Inorganic mixture with following chemical composition: (20-5-10) with fifty percent (50%) sulfur coated urea (no iron), or as recommended by testing lab based on soil sample results.

2.2 PESTICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by Project Manager and authorities having jurisdiction.
   1. Pre-Emergent Herbicide (Selective and Non-Selective): Use only with approval by Project Manager. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
   2. Post-Emergent Herbicide: Glyphosate or 2,4-D, or approved equal.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
   1. Verify that finish grades are consistent with the slopes and grades indicated on the Contract Drawings. Verify grades are in conformance with Division 31 Section “Earth Moving”.

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2. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

3. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

4. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

5. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected and approved by the Project Manager.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Engineer and replace with new planting soil.

D. Beginning of installation means acceptance of existing conditions by the Contractor.

3.2 PREPARATION

A. Work notification: Notify the Project Manager at least seven (7) working days prior to start of sodding operations.

B. Limit turf subgrade preparation to areas that can be sodded within twenty four (24) hours.

C. Newly Graded Subgrades: Prepare soil as required by Division 32 Section “Soil Preparation”.

D. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
   1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
   2. Loosen surface soil to a depth of at least 8 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top six inches (6") of soil. Till soil to a homogeneous mixture of fine texture.
   3. Remove stones larger than one-half (½") inch in any dimension and sticks, roots, trash, and other extraneous matter.
   4. Legally dispose of waste material, including grass, vegetation, and turf, off Town property.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Verify that all areas are graded to drain at a minimum of two percent (2%) or as indicated on the Contract Drawings. Verify that subsurface drainage system and drain inlets if any, are operative.

G. Verify that irrigation system is operable and provides adequate coverage prior to planting.

H. Adjustment: Adjust irrigation heads to proper watering height according to depth of sod material but lower than compacted blade height to enable lawn mowers to cut grass freely without damage to the sprinkler system.

I. When completed, the soil shall be firmed by float dragging, followed by steel raking, to provide for the proper sodded subgrade. The sod bed shall be totally free from rock or clay clods over one-half inch (1/2") inch in diameter.

J. Repair: Re-establish grade and specified conditions to damaged sod areas prior to placing sod.

3.3 INSTALLATION

A. Sodding:
   1. Sod within twenty-four (24) hours after preparation of bed.
2. If plastic netting is present within sod, remove all netting during sod installation and discard from site.
3. Subgrade on which sod is laid shall be slightly moist during installation.
4. Lay sod with longest dimension parallel to contours and in continuous rows.
5. Tightly butt ends and sides of sod together. Stagger and compact vertical joints between sod strips.
6. Sod shall not be overlapped or stretched during placement. Exposed joints due to shrinkage will require replacement of sod in affected areas.

B. Topsoil: Where new sod abuts an existing turf area topsoil shall be placed along seams and or joints to provide a smooth transition.

C. Rolling: Sod shall be rolled after installation to ensure proper contact with the subgrade, and to ensure tight joints between adjacent pieces. Sod shall be moist prior to rolling. Once rolling is complete additional watering shall occur. Roller shall weigh one-hundred (100) pounds.

D. Drainage: Contractor shall ensure that finished areas are graded so that positive drainage of storm and irrigation water is achieved.

E. Water: Contractor to utilize the existing irrigation system and or quick coupler(s) when available. If irrigation or quick coupler(s) are not available then the contractor is responsible for watering. Refer to Division 31 Section “Watering”. Water shall be free of substances that may be harmful to sod growth. Hoses and other watering equipment necessary to water the sod to be furnished by Contractor.
1. Water thoroughly with a fine spray as laying progresses and immediately after planting. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (1-1/2”) below sod.

F. After sod and soil have dried, roll sodded areas to ensure a good bond between sod and soil and to remove minor depressions and irregularities. Roller shall not exceed one hundred (100) pounds.

3.4 CLEANING

A. Perform cleaning during installation of the Work and upon completion of the Work to the satisfaction of the Project Manager. Remove all excess materials, debris, and equipment from site. Repair any damage resulting from sodding operations.

3.5 PROTECTION

A. Protect existing utilities, paving and other facilities from damage caused by sodding operations, the Contractor shall repair any damage at no additional cost to the Town.

B. Restrict vehicular and pedestrian traffic from sodded areas until grass is established. Erect signs and barriers as required or directed by the Project Manager at no additional cost to the Town.

C. Locate, protect and maintain the irrigation system during sodding operations. Repair irrigation system components damaged during sodding operations shall be replaced or repaired to current Town of Erie irrigation standards at the Contractor’s expense.

D. Erosion Control: Take measures and furnish equipment and labor necessary to control and prevent soil erosion, blowing soil and accumulation of wind-deposited materials on the site throughout the duration of work.
3.6 MAINTENANCE

A. General: The maintenance period shall begin immediately after each area is sodded and continue for Sixty (60) days or as determined by the Project Manager. During this time, the Contractor is responsible for watering, mowing, spraying, weeding, fertilizing and all related work as necessary to ensure that sodded areas are in a vigorous growing condition. Provide all supervision, labor, material and equipment to develop and maintain sodded areas from time of installation.

B. Mowing and Trimming: When turfgrasses reach three and one-half inches (3-1/2") in height, begin weekly mowing program to maintain turf at two and one-half inches (2-1/2") to three inches (3") in height. Do not remove more than 1/3 the height of the grass blade in single mowing. Do not mow when grass is wet. All clippings from adjacent paved areas shall be removed and clippings from mowed turf areas shall be removed to the satisfaction of Project Manager.

C. Fertilizing: Within thirty (30) days of sodding and every sixty (60) days thereafter until Acceptance, apply specified fertilizer to maintain optimal turf vigor or per the direction of the Project Manager.

D. Weed Control: Control annual weeds by mowing. Do not use pesticides unless approved by the Project Manager.

E. Insect and Disease Control: As needed, apply insecticide and fungicide approved by the Project Manager and the Parks Operations Supervisor.

3.7 ACCEPTANCE

A. Substantial Completion of sod areas will not be given until the Project Manager is satisfied with establishment and a full stand of grass, in a vigorous growing condition, and thoroughly rooted to the soil and absence of visible joints. The sodded areas shall be accepted on the basis of having a healthy, uniform stand of turf over the entire sodded area.

1. Sixty (60) days after sodding, the sodded areas shall be reviewed by the Project Manager and the Contractor. Any areas as determined by the Project Manager where the sod has failed to establish shall be re-sodded.

B. Final Acceptance will be defined as a healthy uniform turf that does not contain any stressed or bare spots greater than one (1) square foot.

END OF SECTION
SECTION 32 9243
TREES

PART 1 GENERAL

1.01 DESCRIPTION

A. The work of this section consists of providing, installing, and maintaining plant material.

1.02 SUBMITTALS

A. See Section 01 3000-Administrative Requirements, for submittal procedures.
B. Delivery tickets for all bulk materials with Owner's Representative's approval or acknowledgment that materials were received in satisfactory condition.

B. Product certificates signed by manufacturers certifying that their products comply with specified requirements.
   1. Manufacturer's certified analysis for standard products, where applicable.
   2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

B. Samples: 1 cubic foot of mulch required for the project, in labeled plastic bags, boxes, or buckets.

C. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of Landscape Architects and Owners, and other information specified.

D. Material test reports from qualified independent testing agency, indicating and interpreting test results relative to compliance of the following materials with requirements indicated.

E. Analysis of existing surface soil for plant growth per Section 329113 – Soil Preparation.

F. Planting schedule indicating anticipated dates and locations for each type of planting.

G. Copy of a written warranty stating all items included in the warranty, conditions of the warranty, and beginning and ending of warranty period(s).

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.

B. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.

C. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Owner's Representative's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.

D. Provide quality, size, genus, species, and variety of trees indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock", and all applicable state and local rules and regulations.
E. Inspection: Owner's Representative may inspect plants either at place of growth or at site before planting, for compliance with requirements for name, variety, size, and quality.

   1. The Owner's Representative reserves the right to reject at any time or place prior to final acceptance all plant materials, which in the Owner's Representative’s opinion fail to meet specifications. Inspection of materials is primarily for quality, size, and variety, but other requirements are not waived even though visual inspection results in approval. Plants are to be inspected where available; however, inspection at the places of supply shall not preclude the right of rejection at the site or at a later time prior to final acceptance. Rejected material shall be removed from the site within 24 hours.

   2. The Contractor shall schedule inspection of the plants, at either the supplier or on-site, to be completed in one visit. Any further inspection required due to plants being unavailable or rejected as not meeting specifications shall be charged to the Contractor.

F. Measurements: Measure trees according to ANSI Z60.1 with branches and trunks in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree for height and spread; do not measure branches or roots tip-to-tip.

G. Pre-installation Conference: Contractor shall attend pre-installation conference at location specified by Owner's Representative.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site. The Owner's Representative reserves the right to inspect containers before or after installation to verify compliance with Specifications.

B. Trees: Deliver nursery stocked or freshly dug trees. Do not prune before delivery, except as approved by Owner's Representative. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy natural shape. Provide protective covering during delivery. Plant materials delivered without protective covering may be rejected. Do not drop trees during delivery. Label at least one tree of each variety with a securely attached waterproof tag bearing a legible plant name. Remove all tags and flagging as directed by Owner's Representative.

C. Handle balled and burlapped stock by the root ball only.

D. Deliver trees after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.

   1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

   2. Do not remove container-grown stock from containers before time of planting.

   3. Water root systems of trees stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.05 PROJECT CONDITIONS

A. Utilities: Determine location of above grade and underground utilities and perform work in a manner that will avoid damage. Hand excavate, as required. Maintain grade stakes until their removal is mutually agreed upon by parties concerned. Contractor shall be responsible for utility locating, repair of utilities damaged by Contractor, and establishment of grade controls.

B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Owner's Representative before planting.
C. Protection: Erect and maintain barricades, warning signs and lights, and provide guards as necessary or required to protect all persons on the site.

1.06 COORDINATION AND SCHEDULING

A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required. Planting materials should be planted between April 15 and October 1. If irrigation is not available at the time of planting then the Contractor is responsible for watering of all plant material at no additional cost.

B. Plant trees after final grades have been accepted and prior to planting turf, unless otherwise authorized by Owner’s Representative.

1.07 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner 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. Replace planting materials that do not meet product requirements, that may be excessively pruned, more than 20% dead, or in an unhealthy or declining condition immediately upon notice from the Owner’s Representative.

C. All plants shall be true to name and meet all conditions of these specifications. Any plant that is not true to name as indicated by form, leaf, flower, or fruiting characteristics shall be replaced at the Contractor’s expense.

D. The warranty shall not be enforced should any plant die due to vandalism after Final Acceptance.

1.08 FINAL ACCEPTANCE

A. Planted areas will be inspected upon completion and accepted subject to compliance with specified materials and installation requirements. At this time Contractor shall receive a Final Acceptance from the Owner’s Representative. The warranty period will begin upon notification of Final Acceptance.

1.09 TREE MAINTENANCE DURING CONSTRUCTION PERIOD

A. Maintain trees by pruning, cultivating, watering, winter watering, weeding, restoring planting saucers, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees free of insects and disease. Restore or replace damaged tree wrappings. Trees shall be maintained until Final Acceptance of the entire project.

PART 2 PRODUCTS

2.01 PLANT MATERIALS

A. General: Furnish nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully-branched, healthy, vigorous stock free of disease, insects, eggs, larvae, girdling, and defects such as sun scald, injuries, abrasions, and disfigurement. Trees of a larger size may be used if acceptable to Owner’s Representative with a proportionate increase in size of roots and balls.
B. Label at least 1 plant of each variety and caliper with a securely attached waterproof tag bearing legible designation of botanical and common name.

C. All plants shall be the species designated on the Drawings. No substitutions will be accepted without the prior written approval of the Owner's Representative. Contractor must provide proof of non-availability.

2.02 TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required.
   1. Branching Height: 1/3 to ½ of tree height.

B. Provide balled and burlapped trees. Container-grown trees will be acceptable in lieu of balled and burlapped trees subject to meeting ANSI Z60.1 limitations for container stock.

C. All deciduous trees of one species used in formal rows or groupings shall exhibit cultural uniformity, i.e. “matched” in height, crown width and shape, height to first branch, and trunk taper. For this reason it is desired that these trees be produced by a single grower.

2.03 MULCH

A. Organic Mulch: Organic non-dyed mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of chipped or shredded wood material not larger than three inches (3") in length and one-half inch (1/2") in diameter. The following materials are not acceptable as mulch: bark, elm, redwood, newspaper, and plastic. Submit 1.0 CF sample for approval.

2.04 PLANT BACKFILL MATERIAL

A. The plant pit backfill material shall consist of the following, thoroughly mixed:
   1. Soil originally excavated from the pit (two thirds portion of total mix)
   2. Compost material as specified in Section 329113 – Soil Preparation, 2.01A.1.

B. Topsoil shall meet the requirements specified in Section 329113 – Soil Preparation.

2.05 WATER

A. Water will be available from on-site quick couplers during the irrigation season (generally May through September). Contractor shall supply water when system is not charged.

B. Water shall not contain any substances injurious to plant growth.

2.06 MISCELLANEOUS MATERIALS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's instructions.

B. Pre-Emergent Herbicide: Treflan as manufactured by Elanco Company, or an approved substitution.

C. Trunk-Wrap Tape: Two layers of crinkled paper cemented together with bituminous material, 4 inches (102 mm) wide minimum, with stretch factor of 33 percent.

D. Herbicides and Pesticides: EPA registered and approved, of type recommended by manufacturer.

E. Tree Stakes: 6' steel T-posts, color green, or 2" x 2" wood posts, min. 6' long.

G. Tree Ties: Grommeted nylon straps, 1 ½" wide.

H. Staking Wire: Fourteen (14) or sixteen (16) gauge or larger galvanized steel.

I. Organic Mulch: Undyed natural organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of chipped bark and/or wood material not larger than three inches (3") in length/dimension. Submit 1.0 CF sample for approval.

J. Steel Edger and Steel Edger in Lawn: Steel edger shall be commercial type roll-top steel edging. 3/16" x 4" height x 16' length with tapered steel stakes supplied by the manufacturer (Ryerson, or approved substitute). The color of the steel edging should be the following: Black. Submit a 1 foot long sample to Landscape Architect for approval prior to installation.


L. Steel Angle Paver Trim – Steel angle frame shall be commercial type steel 3/16" x 4" height x 2 1/2' length. Submit a 1 foot long sample to Landscape Architect for approval prior to installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Cooperate with any other contractors and trades which may be working in and adjacent to the landscape work areas. Examine drawings which show the development of the entire site and become familiar with the scope of all work required.

3.02 FINISH AND FINE GRADING

A. Tillable Soil: Mechanically rip or disk subsoil in all areas to be planted to minimum depth of 6 inches prior to placing topsoil and soil amendments. Except within the driplines of existing trees.

B. Positive Surface Drainage: Finish and fine grade the project area to establish an even and well matched gradient over the entire surface. Provide positive surface drainage, with no depressions, settling, or irregularities in the finished grade.

C. Transitional Areas: At any transitional point or line where one plane intersects another, such as from a sloping area or berm to a level area, a smooth and gentle transition shall be made. There shall be no abrupt changes in grade unless specifically noted otherwise. Match the grades of new work with existing areas outside the project area.

D. Finish Grade Tolerance: The finish grade elevation shall not vary above or below the proposed grade more than 0.05 foot.

3.03 PREPARATION
A. Lay out individual tree locations and areas for multiple plantings. Stake locations, outline areas, and secure Owner’s Representative’s acceptance before the start of planting work. Make adjustments as directed at no additional cost to the Owner.

3.04 WEED CONTROL
A. In areas that have been regraded and/or have existing weed growth, weed control measures appropriate to the amount of growth and/or species shall be provided. Submit weed control plan to Owner's Representative for approval.

B. Clear and grub, apply pre-emergent herbicide, and/or apply post emergent herbicide as necessary to eliminate weeds. Do not proceed with landscape work until weed growth has been controlled.

3.05 TOPSOIL PLACEMENT
A. Place topsoil to a depth of 4" below top of wall or top of curb on all planter beds.

3.06 EXCAVATION FOR PLANT MATERIAL
A. Planting Pits: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Roughen sides of planting pit.
   1. Balled and Burlapped Trees: Excavate approximately 2 times as wide as ball diameter. The depth of the plant pit shall be 2 inches less than the depth of the ball in well drained soils and 4 inches less than the ball depth in poorly drained soils.
   2. Container-Grown Trees and Shrubs: Excavate approximately 2 times as wide as container diameter. The depth of all plant pits shall be 1 inch less than depth of container.
   3. Where drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.

B. Obstructions: Notify Owner's Representative if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavation.

C. Drainage: Notify Owner's Representative if subsoil conditions show evidence of water seepage or retention in tree or shrub pits.
   1. Fill the pit with water and allow it to completely drain before planting occurs.
   2. If water does not drain out of pit within 24 hours, notify Owner's Representative.

3.07 PLANTING MATERIAL
A. Balled and Burlapped Stock:
   1. Set balled and burlapped stock plumb and in center of pit with top of ball raised above adjacent finish grades as indicated.
   2. Remove burlap from tops of balls and partially from sides, but do not remove from under balls. Remove wire baskets entirely. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation.
   3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. Create 48” diameter saucer around tree and fill with 4” specified wood mulch.

B. Container Grown Stock:
   1. Carefully remove containers so as not to damage root balls.
   2. Lightly scratch sides of exposed root ball to loosen surface roots.
3. Set plants plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
4. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.
5. Mulch at planting bed as shown on drawings.

3.08 PRUNING OF PLANTS

A. Prune, thin, remove injured or dead branches, and shape plants as directed by Owner's Representative.

3.09 MULCHING

A. Mulch backfilled surfaces of pits, planted areas, non-irrigated zones, and other areas indicated.

B. Pre-Emergent Herbicide: Apply pre-emergent herbicide to all shrub bed areas at the rate recommended by the manufacturer. Do not apply to annual, perennial, or ground cover areas.

C. Mulch in shrub bed areas: Apply 4" thick layer of mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.

3.10 INSTALLATION OF MISCELLANEOUS MATERIALS

A. Apply antidesiccant using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage.

1. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

3.11 CLEANUP AND PROTECTION

A. During landscaping, keep pavements clean and work area in an orderly condition.

B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

C. At the time of the final inspection of the work, clean all paved areas by sweeping and washing. Remove construction equipment, excess materials, debris or rubbish from the site.

3.12 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION
SECTION 32 9300
PLANTS

PART 1 GENERAL

1.01 DESCRIPTION

A. The work of this section consists of providing, installing, and maintaining plant material.

1.02 SUBMITTALS

A. See Section 01 3000-Administrative Requirements, for submittal procedures.
B. Delivery tickets for all bulk materials with Owner's Representative's approval or acknowledgment that materials were received in satisfactory condition.

B. Product certificates signed by manufacturers certifying that their products comply with specified requirements.
   1. Manufacturer's certified analysis for standard products, where applicable.
   2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

B. Samples: 1 cubic foot of mulch required for the project, in labeled plastic bags, boxes, or buckets.

C. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of Landscape Architects and Owners, and other information specified.

D. Material test reports from qualified independent testing agency, indicating and interpreting test results relative to compliance of the following materials with requirements indicated.

E. Analysis of existing surface soil for plant growth per Section 329113 – Soil Preparation.

F. Planting schedule indicating anticipated dates and locations for each type of planting.

G. Copy of a written warranty stating all items included in the warranty, conditions of the warranty, and beginning and ending of warranty period(s).

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.

B. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.

C. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Owner's Representative's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.

D. Provide quality, size, genus, species, and variety of trees indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock", and all applicable state and local rules and regulations.
E. Inspection: Owner's Representative may inspect plants either at place of growth or at site before planting, for compliance with requirements for name, variety, size, and quality.

1. The Owner's Representative reserves the right to reject at any time or place prior to final acceptance all plant materials, which in the Owner's Representative’s opinion fail to meet specifications. Inspection of materials is primarily for quality, size, and variety, but other requirements are not waived even though visual inspection results in approval. Plants are to be inspected where available; however, inspection at the places of supply shall not preclude the right of rejection at the site or at a later time prior to final acceptance. Rejected material shall be removed from the site within 24 hours.

2. The Contractor shall schedule inspection of the plants, at either the supplier or on-site, to be completed in one visit. Any further inspection required due to plants being unavailable or rejected as not meeting specifications shall be charged to the Contractor.

F. Measurements: Measure trees according to ANSI Z60.1 with branches and trunks in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree for height and spread; do not measure branches or roots tip-to-tip.

G. Pre-installation Conference: Contractor shall attend pre-installation conference at location specified by Owner's Representative.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site. The Owner's Representative reserves the right to inspect containers before or after installation to verify compliance with Specifications.

B. Trees: Deliver nursery stock ed or freshly dug trees. Do not prune before delivery, except as approved by Owner's Representative. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy natural shape. Provide protective covering during delivery. Plant materials delivered without protective covering may be rejected. Do not drop trees during delivery. Label at least one tree of each variety with a securely attached waterproof tag bearing a legible plant name. Remove all tags and flagging as directed by Owner's Representative.

C. Handle balled and burlapped stock by the root ball only.

D. Deliver trees after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

2. Do not remove container-grown stock from containers before time of planting.

3. Water root systems of trees stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.05 PROJECT CONDITIONS

A. Utilities: Determine location of above grade and underground utilities and perform work in a manner that will avoid damage. Hand excavate, as required. Maintain grade stakes until their removal is mutually agreed upon by parties concerned. Contractor shall be responsible for utility locating, repair of utilities damaged by Contractor, and establishment of grade controls.

B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Owner's Representative before planting.
C. Protection: Erect and maintain barricades, warning signs and lights, and provide guards as necessary or required to protect all persons on the site.

1.06 COORDINATION AND SCHEDULING

A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required. Planting materials should be planted between April 15 and October 1. If irrigation is not available at the time of planting then the Contractor is responsible for watering of all plant material at no additional cost.

B. Plant trees after final grades have been accepted and prior to planting turf, unless otherwise authorized by Owner's Representative.

1.07 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner 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. Replace planting materials that do not meet product requirements, that may be excessively pruned, more than 20% dead, or in an unhealthy or declining condition immediately upon notice from the Owner's Representative.

C. All plants shall be true to name and meet all conditions of these specifications. Any plant that is not true to name as indicated by form, leaf, flower, or fruiting characteristics shall be replaced at the Contractor’s expense.

D. The warranty shall not be enforced should any plant die due to vandalism after Final Acceptance.

1.08 FINAL ACCEPTANCE

A. Planted areas will be inspected upon completion and accepted subject to compliance with specified materials and installation requirements. At this time Contractor shall receive a Final Acceptance from the Owner’s Representative. The warranty period will begin upon notification of Final Acceptance.

1.09 TREE MAINTENANCE DURING CONSTRUCTION PERIOD

A. Maintain trees by pruning, cultivating, watering, winter watering, weeding, restoring planting saucers, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees free of insects and disease. Restore or replace damaged tree wrappings. Trees shall be maintained until Final Acceptance of the entire project.

PART 2 PRODUCTS

2.01 PLANT MATERIALS

A. General: Furnish nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully-branched, healthy, vigorous stock free of disease, insects, eggs, larvae, girdling, and defects such as sun scald, injuries, abrasions, and disfigurement. Trees of a larger size may be used if acceptable to Owner's Representative with a proportionate increase in size of roots and balls.

B. Label at least 1 plant of each variety and caliper with a securely attached waterproof tag bearing legible designation of botanical and common name.
C. All plants shall be the species designated on the Drawings. No substitutions will be accepted without the prior written approval of the Owner's Representative. Contractor must provide proof of non-availability.

2.02 TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required.
   1. Branching Height: 1/3 to 1/2 of tree height.

B. Provide balled and burlapped trees. Container-grown trees will be acceptable in lieu of balled and burlapped trees subject to meeting ANSI Z60.1 limitations for container stock.

C. All deciduous trees of one species used in formal rows or groupings shall exhibit cultural uniformity, i.e. "matched" in height, crown width and shape, height to first branch, and trunk taper. For this reason it is desired that these trees be produced by a single grower.

2.03 MULCH

A. Organic Mulch: Organic non-dyed mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of chipped or shredded wood material not larger than three inches (3") in length and one-half inch (1/2") in diameter. The following materials are not acceptable as mulch: bark, elm, redwood, newspaper, and plastic. Submit 1.0 CF sample for approval.

2.04 PLANT BACKFILL MATERIAL

A. The plant pit backfill material shall consist of the following, thoroughly mixed:
   1. Soil originally excavated from the pit (two thirds portion of total mix)
   2. Compost material as specified in Section 329113 – Soil Preparation, 2.01A.1.

B. Topsoil shall meet the requirements specified in Section 329113 – Soil Preparation.

2.05 WATER

A. Water will be available from on-site quick couplers during the irrigation season (generally May through September). Contractor shall supply water when system is not charged.

B. Water shall not contain any substances injurious to plant growth.

2.06 MISCELLANEOUS MATERIALS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's instructions.

B. Pre-Emergent Herbicide: Treflan as manufactured by Elanco Company, or an approved substitution.

C. Trunk-Wrap Tape: Two layers of crinkled paper cemented together with bituminous material, 4 inches (102 mm) wide minimum, with stretch factor of 33 percent.

D. Herbicides and Pesticides: EPA registered and approved, of type recommended by manufacturer.

E. Tree Stakes: 6' steel T-posts, color green, or 2" x 2" wood posts, min. 6' long.


G. Tree Ties: Grommeted nylon straps, 1 1/2" wide.
H. Staking Wire: Fourteen (14) or sixteen (16) gauge or larger galvanized steel.

I. Organic Mulch: Undyed natural organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of chipped bark and/or wood material not larger than three inches (3”) in length/dimension. Submit 1.0 CF sample for approval.

J. Steel Edger and Steel Edger in Lawn: Steel edger shall be commercial type roll-top steel edging. 3/16” x 4” height x 16’ length with tapered steel stakes supplied by the manufacturer (Ryerson, or approved substitute). The color of the steel edging should be the following: Black. Submit a 1 foot long sample to Landscape Architect for approval prior to installation.


L. Steel Angle Paver Trim – Steel angle frame shall be commercial type steel 3/16” x 4” height x 2 1/2’ length. Submit a 1 foot long sample to Landscape Architect for approval prior to installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Cooperate with any other contractors and trades which may be working in and adjacent to the landscape work areas. Examine drawings which show the development of the entire site and become familiar with the scope of all work required.

3.02 FINISH AND FINE GRADING

A. Tillable Soil: Mechanically rip or disk subsoil in all areas to be planted to minimum depth of 6 inches prior to placing topsoil and soil amendments. Except within the driplines of existing trees.

B. Positive Surface Drainage: Finish and fine grade the project area to establish an even and well matched gradient over the entire surface. Provide positive surface drainage, with no depressions, settling, or irregularities in the finished grade.

C. Transitional Areas: At any transitional point or line where one plane intersects another, such as from a sloping area or berm to a level area, a smooth and gentle transition shall be made. There shall be no abrupt changes in grade unless specifically noted otherwise. Match the grades of new work with existing areas outside the project area.

D. Finish Grade Tolerance: The finish grade elevation shall not vary above or below the proposed grade more than 0.05 foot.

3.03 PREPARATION

A. Lay out individual tree locations and areas for multiple plantings. Stake locations, outline areas, and secure Owner’s Representative's acceptance before the start of planting work. Make adjustments as directed at no additional cost to the Owner.

3.04 WEED CONTROL
3.05 TOPSOIL PLACEMENT
A. Place topsoil to a depth of 4" below top of wall or top of curb on all planter beds.

3.06 EXCAVATION FOR PLANT MATERIAL
A. Planting Pits: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Roughen sides of planting pit.
1. Ball and Burlapped Trees: Excavate approximately 2 times as wide as ball diameter. The depth of the plant pit shall be 2 inches less than the depth of the ball in well drained soils and 4 inches less than the ball depth in poorly drained soils.
2. Container-Grown Trees and Shrubs: Excavate approximately 2 times as wide as container diameter. The depth of all plant pits shall be 1 inch less than depth of container.
3. Where drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
B. Obstructions: Notify Owner’s Representative if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavation.
C. Drainage: Notify Owner’s Representative if subsoil conditions show evidence of water seepage or retention in tree or shrub pits.
1. Fill the pit with water and allow it to completely drain before planting occurs.
2. If water does not drain out of pit within 24 hours, notify Owner’s Representative.

3.07 PLANTING MATERIAL
A. Ball and Burlapped Stock:
1. Set ball and burlapped stock plumb and in center of pit with top of ball raised above adjacent finish grades as indicated.
2. Remove burlap from tops of balls and partially from sides, but do not remove from under balls. Remove wire baskets entirely. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation.
3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. Create 48” diameter saucer around tree and fill with 4” specified wood mulch.
B. Container Grown Stock:
1. Carefully remove containers so as not to damage root balls.
2. Lightly scratch sides of exposed root ball to loosen surface roots.
3. Set plants plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
4. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.
5. Mulch at planting bed as shown on drawings.

3.08 PRUNING OF PLANTS

A. Prune, thin, remove injured or dead branches, and shape plants as directed by Owner's Representative.

3.09 MULCHING

A. Mulch backfilled surfaces of pits, planted areas, non-irrigated zones, and other areas indicated.

B. Pre-Emergent Herbicide: Apply pre-emergent herbicide to all shrub bed areas at the rate recommended by the manufacturer. Do not apply to annual, perennial, or ground cover areas.

C. Mulch in shrub bed areas: Apply 4” thick layer of mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.

3.10 INSTALLATION OF MISCELLANEOUS MATERIALS

A. Apply antidesiccant using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage.

   1. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

3.11 CLEANUP AND PROTECTION

A. During landscaping, keep pavements clean and work area in an orderly condition.

B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

C. At the time of the final inspection of the work, clean all paved areas by sweeping and washing. Remove construction equipment, excess materials, debris or rubbish from the site.

3.12 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION
PART 1 GENERAL

1.1 SECTION INCLUDES

A. Buried pipe, fittings, hydrants, valves, appurtenances, and associated accessories for water distribution
B. Precast vaults
C. Disinfection of potable water piping

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)
   3. A53 – Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
   5. A185 – Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement
   6. A242 – Standard Specification for High-Strength Low-Allow Structural Steel
   8. A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
   11. A674 – Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids
   12. A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   14. B62 – Standard Specification for Composition Bronze or Ounce Metal Castings
   18. B843 – Magnesium Alloy Anodes for Cathodic Protection
   22. C913 – Standard Specification for Precast Concrete Water and Wastewater Structures
   23. C1227 – Standard Specification for Precast Concrete Septic Tanks
   25. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kn-m/m³))
   27. D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
   29. D1351 – Standard Specification for Thermoplastic Polyethylene Insulation for Electrical Wire and Cable
   32. D2000 – Standard Classification System for Rubber Products in Automotive Applications
33. D2239 – Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
34. D2241 – Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
38. D2774 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping
39. D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
40. D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
44. D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
46. D3950 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
47. D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
51. F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
52. F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

B. American Water Works Association (AWWA)
1. B300 – Standard for Hypochlorites
2. B301 – Standard for Liquid Chlorine
3. B302 – Standard for Ammonium Sulfate
14. C200 – Standard for Steel Water Pipe 6 In. (150 mm) and Larger
16. C206 – Standard for Field Welding of Steel Water Pipe
17. C207 – Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)
19. C214 – Standard for Tape Coatings for Steel Water Pipelines
20. C219 – Standard for Bolted, Sleeve-Type Couplings for Plain-End Pipe
22. C502 – Standard for Dry-Barrel Fire Hydrants
25. C515 – Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
27. C600 – Standard for Installation of Ductile Iron Mains and Their Appurtenances
28. C604 – Standard for Installation of Buried Steel Water Pipe – 4 In. (100 mm) and Larger
29. C605 – Standard for Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
30. C651 – Disinfecting Water Mains
31. C700 – Standard for Cold-Water Meters – Displacement Type, Metal Alloy Main Case
32. C800 – Standard for Underground Service Line Valves and Fittings
33. C900 – Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm) for Water Transmission and Distribution
34. C901 – Standard for Polyethylene (PE) Pressure Pipe and Tubing 1/2 In. (13 mm) Through 3 In. (76 mm) for Water Service
35. C905 – Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm) for Water Transmission and Distribution
36. C906 – Polyethylene (PE) Pressure Pipe and Fittings 4 in. (100 mm) Through 63 In. (1,600 mm) for Water Distribution and Transmission
38. M17 – Standard for Installation, Field Testing, and Maintenance of Fire Hydrants
40. M41 – Standard for Ductile-Iron Pipe and Fittings

C. Colorado Department of Transportation (CDOT)
D. National Fire Protection Agency (NFPA)
E. Occupational Safety and Health Administration (OSHA)
F. NSF International:
   1. Standard 60 – Drinking Water Treatment Chemicals – Health Effects
   2. Standard 61 – Drinking Water System Components – Health Effects
G. Surface Preparation Standards (SSPC)
H. American Welding Society (AWS):
   1. D1.1 – Structural Welding Code – Steel
I. National Association of Corrosion Engineers (NACE):
   1. SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
   2. SP0286 – Electrical Isolation of Cathodically Protected Pipelines
J. Uni-Bell PVC Pipe Association:
   1. Uni-Pub-8: Tapping Guide for PVC Pressure Pipe
K. Plastics Pipe Institute (PPI):
   1. TR-4 – HDB / HDS / SDB / PDB / MRS Ratings for Thermoplastic Piping Materials or Pipe
   2. TR-33 – Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe
   3. Handbook of Polyethylene Pipe
   4. Material Handling Guide
L. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design for Ductile Iron Pipe
M. American Railway Engineering and Maintenance-Of-Way Association (AREMA)
N. International Plumbing Code (IPC)
1.3 SUBMITTALS

A. Submit under provisions of Division 1 Specifications

B. Shop Drawings: Provide piping layout and assembly drawings with fitting dimensions. Provide sufficient information to verify compliance with specifications

C. Shop Drawings: Provide sufficient data to verify compliance with the specifications and to illustrate construction and assembly of precast vault

D. Product Data: Provide manufacturer's catalog information with dimensions, material and assembled weight. Indicate pressure ratings for pipe, fittings, valves
   1. Pipe materials
   2. Special, fitting, and coupling details
   3. Joint restraint system
   4. Valves
   5. Laying and installation schedule
   6. Specifications and data sheets
   7. Affidavits of compliance for protective shop coatings and linings

E. Product Data: Provide manufacturer catalog information on castings, grating, and accessories to indicate compliance with specifications of precast vault

F. Design Data: Include calculations prepared by precast manufacturer indicating design loads and material requirements for reinforcement

G. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and applicable standards. Provide prior to shipment.

H. Test Reports: Submit reports of field pressure and disinfection tests under provisions of Division One

I. Test Reports: Indicate disinfection results comparative to specified requirements

1.4 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 1 Specifications

B. Accurately record actual locations of piping mains, valves, connections, top of pipe elevations, and any mapped or unmapped utilities

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities

D. Disinfection report; record:
   1. Type and form of disinfectant used
   2. Date and time of disinfectant injection start and time of completion
   3. Test locations
   4. Initial and 24 hour disinfectant residuals (quantity in treated water) in parts per million (ppm) or milligram per liter (mg/L) for each outlet tested
   5. Date and time of flushing start and completion
   6. Disinfectant residual after flushing in ppm for each outlet tested

E. Bacteriological report; record:
   1. Date issued, project name, and testing laboratory name, address, and telephone number
   2. Time and date of water sample collection
3. Name of person collecting samples
4. Test locations
5. Initial and 24 hour disinfectant residuals in ppm for each outlet tested
6. Coliform bacteria test results for each outlet tested
7. Bacteriologist’s signature and authority

1.5 QUALITY ASSURANCE

A. Manufacturers shall be experienced in the design and manufacturing of materials specified herein for a minimum period of 5 years
B. All pipe, regardless of diameter, shall be supplied by a single manufacturer
C. Perform Work in accordance with AWWA C651, and the Colorado Department of Public Health and Environment (CDPHE), Larimer County, and Town of Berthoud
D. Contractor shall conduct visual inspection before installation
E. Provide manufacturer’s name and pressure rating marked on piping and valves
F. Provide piping complete with all fittings, jointing materials, supports, joint restraint system, and necessary appurtenances for watertight, fully operational water lines

1.6 REGULATORY REQUIREMENTS

A. Conform to all municipal codes and ordinances, laws and regulations of Larimer County, Town of Berthoud, CDPHE, the notes and details on the drawings and as specified herein, and CDPHE Stormwater Management and/or Construction Dewatering Permit
B. Conform to AWWA C651, as appropriate, and CDPHE Design Criteria for Potable Water Systems for performing the work of this Section
C. In case of apparent conflict, CDPHE requirements govern over these specifications
D. In absence of State and local regulations, International Plumbing Code applies
E. NFPA Compliance: Install fire water systems in accordance with NFPA 24 “Standard for the Installation of Private Fire Service Mains and Their Appurtenances”
F. UL Compliance: Provide fire hydrants that comply with UL 246 “Hydrants for Fire-Protection Service,” and are listed by UL.
G. Contractor, not Owner, shall prepare, submit, pay, and otherwise obtain all necessary permits from all appropriate entities

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1 specifications
B. Delivery
   1. Ship rubber gaskets in cartons and store in a clean area away from grease, oil, ozone producing electric motors, heat and the direct sunlight
C. Storage
   1. Store pipe, fittings and gaskets in clean locations protected from environmental conditions such as: direct sunlight, mud, etc.
   2. Do not use pipe and fittings stored in direct sunlight for periods in excess of 18 months
   3. Store pipe on a flat surface which provides even support for the barrel with bell ends overhanging
a. Do not stack pipe higher than 5 feet

D. Storage: Use the following precautions for valves, during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage
      a. Protect valves from weather by storing indoors or support valves off ground or pavement in watertight enclosures when outdoor storage is necessary

E. Handling
   1. Handle so as to insure installation in sound undamaged condition
   2. Use equipment, tools and methods for unloading, reloading, hauling and laying that do not damage pipe or cause an impact. Damaged pipe will be cause for rejection.
   3. Use hooks or straps with broad, well-padded contact surfaces for lifting sections of pipe

F. Preparation for Transport: Prepare valves, for shipping as follows: Ensure that valves are dry and internally protected against rust and corrosion. Protect valves against damage to threaded ends, flange faces, and weld ends. Set valves in best position for handling. Set valves closed to prevent rattling

G. Deliver and store valves and accessories in shipping containers with labeling in place in accordance with AWWA C500

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

I. Seal valve ends to prevent entry of foreign materials into valve body

J. During loading, transporting and unloading, exercise care to prevent damage to material
   1. Use nylon slings only
   2. Do not drop pipe or fittings
   3. Do not roll or skid against pipe already on ground
   4. Repair any damage done to coating or lining
   5. Handle per manufacturer's recommendations
   6. Store rubber gaskets in cool dark location
   7. Store all material on wood pallets or timbers

K. Adequately tag or otherwise mark all piping, fittings, and valves as to size per AWWA C509, C900, and C905

L. Shop coated materials shall be handled, transported, stored and shipped in a manner that will prevent damage to the coating and lining. Coating or lining damaged in handling or other operations shall be repaired to the approval of and at no additional cost to the Owner

M. Any damage to the pipe or the protective coating from any cause during the installation of the pipeline and before final acceptance by the Engineer shall be repaired in accordance with these Specifications and at no additional cost to the Owner

N. Precast Concrete Structures
   1. Transport and handle precast concrete units with equipment to protect from dirt and damage
   2. Do not place precast concrete units in position which will cause damage
   3. Handle precast concrete structures by means of lifting inserts. Do not move from manufacturer’s yard until curing is complete.

1.8 JOB CONDITIONS

A. All work which requires the interruption of active water service lines must be completed as quickly as possible in order to minimize inconvenience to customers and risk to the Town of Berthoud and coordinated as specified in Division 1

B. Underground Obstructions
   1. Underground Obstructions known to Engineer are shown on Drawings
a. Locations shown may prove inaccurate and other obstructions not known to Engineer may be encountered
b. Contractor shall field locate and verify all obstructions where or not shown on the Drawings
2. Notify each utility owner and request utility be field located by surface reference at least 48 hours prior to trenching or excavation
3. Expose and verify size, location and elevation of underground utilities and other obstructions where conflicts might exist sufficiently in advance to permit changes in the event of a conflict
a. Notify Engineer and Owner in case of a conflict
b. In case of a conflict, the proposed work may be changed by Engineer
4. Maintain, protect, and support by shoring, bracing or other means existing utilities and appurtenances
C. Verify existing system operation, pressures, and valve settings (open or closed) prior to construction

PART 2 PRODUCTS

2.1 PIPE, FITTINGS, AND ACCESSORIES
A. Comply with the most current Town of Berthoud standards and specifications for the public water system products and accessories.

2.2 PVC PIPE – 4” TO 12” DIAMETER
A. Manufacturers:
   1. JM Eagle
   2. Georg Fischer Piping Systems
   3. North American Pipe Corporation
   4. Diamond Plastics Corporation
   5. Vinyltech Corporation
   6. Or accepted substitution
B. The following piping shall be small diameter PVC pipe as indicated on Drawings and as specified herein:
   1. Water distribution mains: 6”, 8” and 12” diameter
   2. Fire hydrant laterals and blow off drain lines: 6” diameter
   3. Diameters: Cast iron pipe equivalent outside diameters
C. Pipe: AWWA C900, DR 18 except as otherwise specified or indicated on the Drawings
D. Marking: Identification markings on pipe shall conform to AWWA C900
E. Fittings: Ductile iron compact fittings: ANSI A 21.53/AWWA C153
   1. Working pressure rating: 350 psi rating
   2. Joint: Mechanical joints with restraints
   3. Coating:
      a. Exterior: AWWA C111, Asphalt coated
      b. Interior: AWWA C104 and C111, lined with double thickness cement seal coated
      c. Or interior and exterior: AWWA C116, fusion bonded epoxy coating
F. Joints: ASTM D3139, integral bell or mechanical joint
   1. Push-on joints: pipe to pipe joints, except as otherwise specified or indicated on Drawings. Push on joints are not permitted on fittings or valves
      a. Integral bell type with elastomeric gaskets, ASTM F477 factory installed
      b. Suitable for buried service
      c. Gaskets:
         i) Material: Virgin SBR rubber suitable for potable water conforming to AWWA C111
         ii) Lubricant shall be suitable for potable water contact
   2. Restraint device for PVC push on joint
      a. Restraint material: ASTM A536, ductile iron
b. A split ring shall be used behind the pipe bell. A serrated ring shall be used to grip the pipe, and a sufficient number of bolts shall be used to connect the bell ring and the gripping ring
c. Nuts and bolts torqued to requirements of manufacturer
d. Pressure rating consistent with pipe pressure rating
e. Restraint coatings shall be consistent with manufacturer's standard
f. Manufacturers:
   i) EBAA Iron Inc. "Series 1600"
   ii) Romac Industries "Series 611"
   iii) Or accepted substitution
3. Mechanical joint restraint
   a. Provide mechanical joint restraint for all ductile iron fittings connecting to PVC pipe
   b. Restraint devices for shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of ANSI/AWWA A21.10/C110
   c. Pressure rating consistent with pipe pressure rating
d. Restraint coatings shall be consistent with manufacturer's standard
e. Manufacturer:
   i) EBAA Iron "MEGALUG 2000 PV"
   ii) Romac Industries "Roma-Grip"
   iii) Or accepted substitution
G. Couplings
1. Mechanical couplings:
   a. Dresser Style 38
   b. Rockwell 411
c. Or accepted substitution
2. Insulated Mechanical Couplings:
   a. Dresser Style 39
   b. Or accepted substitution
3. Transition Couplings:
   a. Rockwell 415
   b. Dresser Style 39
c. Or accepted substitution
4. Glands color coded: Black

2.3 PVC PIPE – 14" TO 48" DIAMETER

A. Manufacturers
1. JM Eagle
2. North American Pipe Corporation
3. Diamond Plastic Industries
4. Vinyltech Corporation
5. Or accepted substitution
B. The following piping shall be large diameter PVC pipe as indicated on Drawings and as specified herein:
   1. Water transmission mains: 18", 24" and 36" diameter
   2. Diameters: Cast iron pipe equivalent outside diameters
C. Pipe: AWWA C905, DR 21 except as otherwise specified or indicated on the Drawings
D. Marking: Identification markings on pipe shall conform to AWWA C905
E. Fittings: Ductile iron fittings, ANSI A 21.53/AWWA C153 or ANSI A21.10/AWWA C110
   1. Working pressure rating: 250 psi rating
   2. Joint: mechanical joints with restraints
   3. Coating:
      a. Exterior: AWWA C111
      b. Asphalt coated interior: AWWA C104 and C111, lined with double thickness cement and seal coated
c. Or interior and exterior: AWWA C116, fusion bonded epoxy coating
F. Joints: ASTM D3139, integral bell or mechanical joint
   1. Push-on joints: pipe to pipe joints, except as otherwise specified or indicated on Drawings. Push on
      joints are not permitted on fittings or valves
      a. Integral bell type with elastomeric gaskets, ASTM F477 factory installed
      b. Suitable for buried service
      c. Gaskets:
         i) Material: Virgin SBR rubber suitable for potable conforming to AWWA C111
         ii) Lubricant shall be suitable for potable water contact
   2. Restraint device for PVC push on joint
      a. Restraint material: ASTM A536, ductile iron
      b. A backup ring shall be used behind the PVC bell. A restraint ring, incorporating a plurality of
         individually-actuating gripping surfaces, shall be used to grip the pipe, and a sufficient number of
         bolts shall be used to connect the bell ring and the gripping ring
      c. Pressure rating consistent with pipe pressure rating
      d. Restraint coatings shall be consistent with manufacturer's standard
      e. Manufacturers:
         i) EBAA Iron Inc. "Series 2800"
         ii) Romac Industries "Series 470"
         iii) Or accepted substitution
   3. Mechanical joint restraint
      a. Provide mechanical joint restraint for all ductile iron fittings connecting to PVC pipe
      b. Restraint devices for shall consist of multiple gripping wedges incorporated into a follower gland
         meeting the applicable requirements of ANSI/AWWA A21.10/ C110
      c. Pressure rating consistent with pipe pressure rating
      d. Restraint coatings shall be consistent with manufacturer's standard
      e. Manufacturer:
         i) EBAA Iron "MEGALUG 2000 PV"
         ii) Romac Industries "Roma-Grip"
         iii) Or accepted substitution

G. Couplings
   1. Mechanical couplings:
      a. Dresser Style 38
      b. Rockwell 411
      c. Or accepted substitution
   2. Insulated Mechanical Couplings:
      a. Dresser Style 39
      b. Or accepted substitution
   3. Transition Couplings:
      a. Rockwell 415
      b. Dresser Style 39
      c. Or accepted substitution
   4. Glands color coded: Black

2.4 PVC SADDLE TAP
   A. Provide saddle tap for connection to air release/vacuum breaker combination valves as shown on the
      Drawings
   B. Use tapping saddle manufactured specifically for C900 and C905 PVC pipe with stainless steel wide band
      straps, nuts and washers
   C. Manufacturer:
      1. Mueller
      2. Or accepted substitution

2.5 HDPE PIPE
   A. Manufacturers
1. JM Eagle
2. High Country Fusion
3. Performance Pipe
4. WL Plastics
5. ISCO Pipe
6. Or accepted substitution

B. The following piping shall be HDPE pipe as indicated on Drawings and as specified herein:
   1. Water transmission mains: 18”, 24” and 36” diameter
   2. Diameters: Cast iron pipe equivalent outside diameters

C. Material
   1. The pipe shall be manufactured from a PE 4710 resin compound listed with the Plastic Pipe Institute (PPI) as TR-4.
   2. The resin material shall be in accordance with ASTM D3350 with a minimum cell classification of 445574C/E.
   3. This resin material shall have a Long Term Hydrostatic Strength of 1600 PSI when tested in accordance to ASTM D2837.
   4. Pipe dimensions shall be in accordance with ASTM D3035 as a minimum.
   5. The final compounded material shall contain a minimum of 2% carbon black
   6. The pipe shall contain no recycled material except that generated by the pipe manufacturer in their own plant from resin compound of the same specification and raw material supplier. The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids, or other injurious defects.
   7. Pipe shall have a manufacturing standard of ASTM F714 and be manufactured by an ISO 9001 certified manufacturer.
   8. All pipes and fittings shall be suitable for use as pressure conduits, listed as NSF 14, and per AWWA C906 Pressure Class (PC) 100 have a nominal burst value of three and one-half times the Working Pressure Rating (WPR) of the pipe and/or fitting.
   9. The pipe shall be DR11 unless noted otherwise on the Drawings

D. Fittings
   1. All fittings shall be PE 4710 HDPE, minimum Cell Classification of 445574C/E as determined by ASTM D3350, and approved for use by AWWA.
   2. All fittings shall be of the same base resin as the pipe.
   3. All fittings shall have a working pressure rating equal to the pipe unless otherwise specified in the plans.
   4. All fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids, or other injurious defects.
   5. Butt Fusion Fittings
      a. Molded butt fusion fittings shall be in accordance with ASTM D3261 and shall be manufactured by injection molding, a combination of extrusion and machining, or fabricated from HDPE pipe conforming to this specification.
   6. Compression Type Mechanical Coupling
      a. Suitable for joining HDPE to HDPE, HDPE to PVC, or HDPE to DIP
      b. Factory coat coupling internally and externally with a fusion bonded epoxy
      c. Reinforce HDPE pipe with a split ring type stiffener in pipe bore
         i) Size stiffeners for size of HDPE pipe being joined
         ii) Supply feature that prevents stiffener from sliding completely into pipe
         iii) Size stiffeners for length of mechanical coupling and not to extend outside of body of mechanical coupling
         iv) Mark stiffener with pipe diameter
         v) Factory coat stiffeners internally and externally with fusion bonded epoxy
      d. Use seal and restraint type coupling. Requirements for type of couplings are specified herein or shown on Drawings
         i) Approved Manufacturers:
         ii) JCM, Industries
         iii) Sur-Grip
         iv) Romac
E. Transition Couplings: One piece assembly
   1. One end being HDPE pipe with butt fusion joining technique
   2. Other end being either steel or brass pipe threaded suitable for connecting ductile iron, threaded fittings, or threaded valves
      a. Approved Manufacturers:
         i) Central Plastics Company
         ii) Industrial Pipe Fittings, Inc.
         iii) Or accepted substitution

F. Pipe fittings and flanged connections, to be joined by thermal butt-fusion, shall be of the same type, grade, and class of polyethylene compound and supplied from the same raw material supplier.

G. Sidewall fusions for connections to outlet piping shall be performed in accordance with HDPE pipe and fitting manufacturer’s specifications. The heating iron used for sidewall fusion shall have an inside diameter equal to the outside diameter of the HDPE pipe being fused. The size of the heating iron shall be ¼ inch larger than the size of the outlet branch being fused.

H. Socket fusion, hot gas fusion, threading, solvents, and epoxies will not be used to join HDPE pipe.

I. Flange Gaskets
   1. Flange gaskets shall be full-faced and shall be in accordance with ASTM D1330
   2. Flange gasket drilling pattern shall conform to ANSI B16.1/B16.5
   3. Flange gaskets shall be 1/16" thick for flanges up to 14" diameter. 1/8" thick gaskets shall be provided for flanges over 14" diameter
   4. Gasket material shall be EPDM

2.6 DUCTILE IRON PIPE

A. Manufacturers
   1. U.S. Pipe
   2. American Cast Iron Pipe Company
   3. Griffin Pipe Products Company
   4. Or accepted substitution

B. The following piping and fittings shall be ductile iron pipe as indicated on Drawings and as specified herein:
   1. Fire Hydrant piping: 6" diameter
   2. Fittings, joints, couplings, and mechanical joints

C. Pipe: ANSI A21.51/AWWA C151:
   1. Class 51, pressure rating 350 psi
   2. For push-on joints, mechanical joints, restrained mechanical joints, or restrained joints: Class 51, single gasket
   3. Lining: cement mortar, AWWA C104
   4. External coating for buried pipe: asphaltic coating, 1 mil

D. Fittings: Ductile iron compact fittings: ANSI A 21.53/AWWA C153
   1. Working pressure rating: 350 psi rating
   2. Joint: Mechanical joints with restraints
   3. Coating:
      a. Exterior: AWWA C111, Asphalt coated
      b. Interior: AWWA C104 and C111, lined with double thickness cement seal coated
      c. Or interior and exterior: AWWA C116, fusion bonded epoxy coating
   4. Tapping Sleeve and Tapping Valve: Complete assembly, including tapping sleeve, tapping valve, and bolts and nuts. Use sleeve and valve compatible with tapping machine.
      a. Tapping Sleeve: Cast-iron or ductile-iron 2-piece bolted sleeve with flanged outlet for new branch connection. Sleeve may have mechanical joint ends with rubber gaskets or sealing rings in sleeve
body. Use sleeves that mate with size and type of pipe material being tapped. Outlet flange shall be of a size required for branch connection.

E. Joints
1. Mechanical joints: ANSI A21.11/AWWA C111
   a. Bolts and nuts: High strength, low alloy steel, "Cor-Ten" or approved substitution
2. Mechanical joints with tie rods
   a. Tie rods: ASTM A307, galvanized entire length
   b. Steel pipe spacers: ASTM A53, standard weight galvanized
   c. Washers: ASTM A27 plain steel, galvanized
   d. Plastic plugs: As recommended by pipe manufacturer
   a. Pressure rated 350 psi
   b. Lubricant: Heavy vegetable soap solution suitable for potable water contact
4. Gaskets: EPDM gaskets in conformance with AWWA C111. Natural rubber is not acceptable.
5. Gaskets: Butyl rubber gaskets in conformance with ANSI A21.11/AWWA C111. Natural rubber is not acceptable.
   a. Pressure rated 350 psi
6. Threaded connections: ANSI B1.20.3 NPT: provide boss or tapping saddle at all tapped connections
7. Mechanical couplings:
   a. Dresser, Style 38
   b. Rockwell, 411
   c. Romac, 501
   d. Or accepted substitution
8. Insulated Mechanical Couplings:
   a. Dresser, Style 39
   b. Rockwell, Style 416
   c. Romac, IC501
   d. Or accepted substitution
9. Mechanical joints with restraint device
   a. Provided for all ductile iron fittings
   b. 360° serration lock engagement type
   c. Nuts and bolts torqued to requirements of manufacturer
   d. Working pressure rated at 350 psi minimum
   e. Glands color coded: Black
   f. Manufacturers:
      i) EBBA Iron Inc., Meg-a-Lug Series 1100
      ii) Uni-Flange Corporation, 1400 Series
      iii) Romac Industries Inc., RomaGrip™
      iv) Or accepted substitution

2.7 COPPER TUBING – 3 INCHES OR LESS

A. Manufacturers:
   1. Mueller
   2. Or accepted substitution

B. Copper Tube: ASTM B88; Type K, soft-annealed temper with flared connections.
   1. Fittings: Wrought-copper solder-joint fittings, ANSI B16.22; soldered joints, pressure type. Compression fitting will not be accepted.

2.8 Q-LINE - 3 INCHES OR LESS

A. Q-line: ASTM F1282; Aluminum tubing permanently bonded between inner and outer layers of raised temperature polyethylene.
   1. Fittings: Red brass fittings per AWWA C800 or polypropylene compression. (Required for SACWSD 8/6/2013)
2.9 POLYETHYLENE TUBING

A. Manufacturers:
   1. Centennial Plastics, Inc.
   2. Or accepted substitution

B. Service lines shall be Polyethylene (PE) Copper Tube Size (CTS) potable water tubing
   1. Service line pipe sizes are indicated on Drawings.
   2. Resin formulation: PE 3608
   3. Cell Classification of 4345464C per ASTM D2239 and ASTM D2737
   4. Hydrostatic Design Basis (HDB)
      a. HDB: 1600 psi @ 73.4 °F
      b. HDB: 800 psi @ 140 °F

C. Joining:
   1. Shall be by butt-fusion
   2. All personnel conducting butt-fusion should be experienced and follow guidelines published by the pipe manufacturer or by PPI in TR-33

D. Installing:
   1. To be direct buried
   2. Buried pipe must be supported by proper embedment material as shown on Drawings
   3. Refer to PPI's "Handbook of Polyethylene Pipe" and follow all local, state, and/or federal guidelines

E. Safe Handling:
   1. To safely handle and store PE pipe, refer to PPI's "Material Handling Guide"

F. Disinfection:
   1. Disinfection of service line should follow specifications herein

G. Testing:
   1. All pipe shall be hydrostatically tested after installation as specified herein.

2.10 SERVICE LINE ACCESSORIES

A. Corporation Stops: AWWA C800, Bronze body and ground key plug. Threaded inlet and outlet matching service piping material
   1. Bronze body and ground key plug. Threaded inlet and outlet matching service piping material.
   2. Manufacturers:
      a. Mueller, H-15013
      b. Ford, FB1000G
      c. A.Y. McDonald, 4701BQ or 4701BT
      d. Or accepted substitution

B. Curb Stops: 2" bronze body and ground key plug. Threaded inlet and outlet matching service piping material.
   1. Manufacturers:
      a. Mueller
      b. Ford
      c. Or accepted substitution

C. Curb box: Arch pattern base, coal tar coated extensions. Include 1 inch tapped hole with a centered plug having a 5/8-inch hexagon nut. Include cover with lettering "WATER."
   1. Manufacturers:
      a. A.Y. McDonald, 5607 with 5601-1 lid
      b. Or accepted substitution

D. Service Clamps: Complete assembly, including double strap service clamp, corporation stop, and bolts and nuts. Use service clamp and stop compatible with drilling machine.
1. Cast iron or ductile iron with gasket and AWWA C800 threaded outlet for corporation stop, and threaded end straps.
2. Manufacturers:
   a. Mueller Co.
   b. Romac Industries, Inc.
   c. Or accepted substitution

E. Meter box: Provide at existing meter locations as indicated on drawings
   1. 18-inch diameter meter box with minimum 0.30-inch thick PVC shell for 3/4" or 1" meter
   2. Lid: cast-iron with closed cell insulating pad
   3. Provide with shell extensions as required to satisfy 9 foot bury depth requirements
   4. Manufacturers:
      a. Mueller Co.
      b. Hunt
      c. Ford
      d. Or accepted substitution

2.11 WELDED STEEL PIPE

A. Casing Pipe
   1. Conforming ASTM A53 and AWWA C200
   2. ASTM A139 Grade B
   3. Minimum yield strength of 35,000 psi
   4. Diameter: 24 inches
   5. Minimum thickness: 0.375 inches
   6. External Coating:
      a. Bituminous asphalt coating in accordance with AWWA C104
   7. Field and shop welds of casing pipes shall be full-circumference welded joints and conform to the American Welding Society standard specifications
   8. Field welds shall be butt-welded, single-bevel groove type joints in accordance with AWWA C206
   9. Welds shall be airtight for the entire circumference of the pipe
   10. Welds shall not increase outside pipe diameter by more than 3/4-inch
   11. Welds shall not intrude into the bore of the casing

B. Performance and Design Criteria
   1. Contractor to design casing pipe wall thickness based on worst condition of any anticipated loads during installation or after construction. Specified thickness for pipe casings are the minimum required regardless of the Contractor design.
   2. Design leakproof casing pipe liner joints. Design for earth and other pressures present, plus highway H20 loading with associated recommended impact loading, plus railway E80 loading with associated recommended impact loading
      a. Highway Crossings: Design tunnel for earth and other pressure loads present, plus AASHTO H20 live loading
      b. Railroad Crossings: Design tunnel for earth and other pressure loads present, plus AREMA E80 live loading with 50 percent added for impact
   3. Design bracing and backstops and use jacks of sufficient rating for continuous jacking without stopping, except to add pipe sections and to minimize tendency of ground material to freeze around casing pipe.
   4. Design steel tunnel lining according to AREMA Manual for Railway Engineering

C. Pipe Spacers
   1. Pipe bands shall be fabricated of a minimum of 14 gauge 304 stainless steel
      a. Steel strapping shall be in accordance with ASTM A36
   2. Hardware:
      a. Bolts: 5/16-inch stainless-steel flange bolts

2.12 CATHODIC PROTECTION

A. Polyethylene encasement
   1. Provide encasement for all ductile iron pipe, fittings, restrained mechanical joints and valves
2. High-density, cross-laminated polyethylene film (minimum 4 mil) or linear low-density polyethylene film (min 8mil)
3. Polyethylene flat tube: meet appropriate minimum width for size of pipe installed per AWWA C105, Method A, secured with polyethylene compatible adhesive tape
4. Flat sheet polyethylene: Provide wrapping odd shaped appurtenance following C105, secured with polyethylene compatible adhesive tape
5. Joint tape: Self-sticking, PVC or polyethylene, 2-inch wide, 10 mils thick
   a. Manufacturer:
      i) Chase "Chasekote 750"
      ii) Kendall "Polyken 900"
      iii) 3M "Scotchrap 50"
      iv) Or accepted substitution
6. Strapping: Nonmetallic, water resistant, ASTM D3950

B. Field applied tape encasement: AWWA C214
   1. Primer: Polyken #927
   2. Tape: Polyken #930 or #934
   3. Apply primer and Polyken wrap for harness rods

2.13 PIPE ACCESSORIES

A. Identification Marker Tape: Provide metallic core tape, blue with black letters “CAUTION – WATER LINE BELOW” continuously printed plastic tape with metallic core, intended for direct-burial service; not less than 6-inch wide x 4 mils thick. Provide identification markers of one of the following:
   1. Allen Systems, Inc.
   2. Emed Co., Inc.
   3. Seton Name Plate Corp.
   4. Or accepted substitution

B. Tracer Wire
   1. Provide tracer wire for all PVC and HDPE pipe
   2. All tracer wire shall be 12 AWG solid copper wire coated with 45 mil Type HMW - PE blue insulation compliant with ASTM D1351 specifically designed for direct burial in corrosive soil or water
   3. UL listed

C. Tracer Wire Test Stations
   1. 4-inch with locking lid
   2. Manufacturers:
      a. CP Test Services
      b. Glenn Series "Glenn-4"
      c. Or accepted substitution

D. Corrosion Control
   1. Rust inhibitive primer:
      a. Tnemec "Series 77H Chem-Prime"
      b. Or accepted substitution
   2. Rust preventative compound:
      a. Houghton "Rust Veto 344"
      b. Rust-Oleum "R-9"
      c. Or accepted substitution

E. Pipe Spacers
   1. Pipe bands shall be fabricated of a minimum of 14 gauge 304 stainless steel
      a. Steel strapping shall be in accordance with ASTM A36
   2. Hardware:
      a. Bolts: 5/16-inch stainless-steel flange bolts

F. Insulators
   1. Polyethylene casing insulator band and skids with stainless-steel bolts
G. End Seals
   1. Fabricated of EPDM or neoprene
   2. Durometer hardness: 60
   3. Minimum thickness: 1/8 inch
   4. Hardware: 304 stainless steel with worm screws
   5. Manufacturers
      a. Advance Products & Systems, Inc.
      b. Pipeline Seal & Insulator, Inc.
      c. Or accepted substitution

2.14 GATE VALVES – 3" TO 12" AND ACCESSORIES

A. Manufacturers:
   1. Mueller
   2. American AVK
   3. American Flow Control
   4. Clow
   5. Kennedy
   6. Or accepted substitution

B. AWWA C509, Iron body, bronze trim, two O-ring stem seals, non-rising stem with square nut, single wedge, resilient seat, mechanical joint ends, extension stem, and extension valve box, pressure rating of 250 psi. For installation in horizontal or near horizontal pipe lines
   1. Non-adjustable elastomeric stem seals
      a. Adjustable packing glands are not permitted
   2. Direct operation of stem from above via 2-inch square nut
      a. No gear box provided
   3. Rotation: Counterclockwise to open with the word "OPEN" and an arrow indicating the direction to open cast on valve body or operating nut

C. Rotation: Contractor to verify the operating direction with the jurisdictional water district or department
   1. Provide the word "OPEN" and an arrow indicating the direction to open cast on valve body or operating nut
   2. Contractor to confirm nut size with the jurisdictional water district or department

D. Valve stem material: ASTM B763, UNS alloy C99500 minimum yield strength of 40,000 psi
   1. Valve stem extensions: Provide valve stem extensions as necessary for proper valve operation with a 7 foot key with tee handle
   2. Provide one (1) key to Owner prior to project closeout

E. Extension stems
   1. Provide for buried valves with operating nuts more than 4.5 feet below grade
   2. Non-rising stems
      a. Solid steel shafting with O.D. not less than O.D. of valve stem or galvanized steel pipe with I.D. not less than O.D. of valve stem
      b. Connected to the valve by a flexible socket coupling
      c. All other connections pinned
      d. Extend stem to within 6-inch of grade
      e. Provide spacers to center stem in valve box
      f. Provide wrench nut

F. Coating
   1. AWWA C550 and NSF 61 certified
   2. Minimum 8 mils dry film thickness
   3. Fusion bonded epoxy applied to all ferrous metal surfaces after cleaning surfaces of grease, dirt and moisture, and performing near-white blast cleaning following SSPC-SP10
   4. Do not coat fasteners or machined surfaces subject to contact and relative movement against other surfaces during operation of valve or other surfaces where such coating would compromise proper installation or functionality of valve
G. Valve boxes, depth as required for valve
   1. Three piece cast iron (complying with ASTM A48, Class 20A) adjustable screw type, 5.25-inch diameter, minimum thickness of 3/16 inch
   2. Box, cover, and base coated by dipping in asphalt varnish.
   3. Cover marked with word, “WATER.”
   4. Provide extension piece to permit 6-inch adjustment above finish grade
   5. Manufacturers:
      a. Tyler Pipe Company "Series 6860 with #160 oval base"
      b. East Jordan Iron Works "8560 Series"
      c. Tyler Union "6860 Series"
      d. Or accepted substitution

2.15 BUTTERFLY VALVES – 16” TO 36” (DIRECT BURY) AND ACCESSORIES

A. Manufacturers:
   1. Pratt
   2. Milliken
   3. Or accepted substitution.

B. AWWA C504 Class 150B for direct bury service
   1. Valve body shall be constructed of cast iron ASTM A126 Class B and conform to AWWA C504 in terms of laying lengths and minimum body shell thickness
   2. Mechanical joint ends following AWWA C111
   3. Valve disc shall be cast iron or ductile iron furnished with Type 316 stainless steel seating edge to mate with rubber seat on body
      a. Valve disc shall seat in position at 90 degrees to pipe axis and shall rotate 90 degrees between full-open and tight-closed position. Install valves with valve shafts horizontal and convex side of disc facing anticipated direction of flow
      b. Disc shall not creep or flutter under service conditions
   4. Seat: Buna-N-Rubber
      a. 16-inch to 18-inch: Bonded seats that meet ASTM D429 Method B
      b. 24-inch and larger: Seats retained in the valve body by mechanical means without metal retainers or other devices located in the flow stream
      c. Retaining hardware for seats: type 304 or 316 stainless steel. Nuts and screws used with clamps and discs for rubber seats shall be held securely with locktite, or other approved method, to prevent loosening by vibration or cavitation effects
   5. Valve Shaft: type 304 SS, ASTM A276
      a. Shaft bearings: stainless steel in accordance with AWWA C504. Design valve shaft to withstand 3 times amount of torque necessary to open valve
      b. Packing: Standard self adjusting and wear compensating, split-V type, and replaceable without removing actuator assembly
   6. Actuators:
      a. Provide manual actuators for single project, from same manufacturer
      b. Shaft connecting actuator to valve body must be fully enclosed. Bonnet and extension to be fully enclosed and water tight
      c. Provide bonnet extensions, as required, between valve body and actuator. Space between actuator housing and valve body shall be completely enclosed so that no moving parts are exposed to soil or elements
      d. Provide actuators for valves with size based on line velocity of 12 feet per second and unidirectional service.
         i) Equip with gear manual actuator
         ii) Fully enclosed, traveling-nut type. Traveling nut shall engage alignment grooves in the housing
         iii) Traveling nut actuator shall be self-locking and designed to transmit twice the required actuator torque without damages to faces of gear teeth or contact faces of nut
      e. Oil-tight and watertight actuator housing for valves, specifically designed for buried service and factory packed with suitable grease
      f. Equipped with 2-inch actuator nut
      g. Rotation: Counterclockwise to open with the word "OPEN" and an arrow indicating the direction to open cast on valve body or operating nut
h. Valve operating key: Provide one (1) for project, 7 foot length with tee handle

7. Coating
   a. Follow AWWA C550 and NSF 61
   b. Coat interior and exterior ferrous surfaces of valve with epoxy suitable for potable water conditions: in accordance with AWWA C550 and coating manufacturer's recommendations
   c. Provide three coats of two component, high-build epoxy with minimum dry film thickness of 12 mils

C. Extension stems
   1. Provide as specified for buried valves with operating nuts more than 4.5 feet below grade
   2. Non-rising stems
      a. Solid steel shafting with O.D. not less than O.D. of valve stem or galvanized steel pipe with I.D. not less than O.D. of valve stem
      b. Connected to the valve by a flexible socket coupling
      c. All other connections pinned
      d. Extend stem to within 6-inch of grade
      e. Provide spacers to center stem in valve box
      f. Provide wrench nut

D. Valve boxes, depth as required for valve
   1. Three piece cast iron (complying with ASTM A48, Class 20A) adjustable screw type, 5.25-inch diameter, minimum thickness of 3/16 inch
   2. Box, cover, and base coated by dipping in asphalt varnish.
   3. Cover marked with word, “WATER.”
   4. Provide extension piece to permit 6-inch adjustment above finish grade
   5. Manufacturers:
      a. Tyler Pipe Company "Series 6860 with #160 oval base"
      b. East Jordan Iron Works "8560 Series"
      c. Tyler Union "6860 Series"
      d. Or accepted substitution

2.16 VALVE INSERTION

A. Manufacturers:
   1. Romac
   2. Or accepted substitution

B. Resilient wedge designed for use in potable water systems

C. The design shall allow the valve to be installed into an existing pressurized pipeline while maintaining constant pressure and service as usual. The valve shall be equipped with a standard handwheel operator.

D. Valve Construction:
   1. The ductile iron body, bonnet, and wedge shall provide a strength and pressure rating that meets or exceeds the requirements of AWWA C515
   2. Valve shall be ductile iron construction and meet ASTM A536 Grade 65-45-12
   3. Chemical and modularity tests shall be performed as recommended by the Ductile Iron Society, on a per ladle basis. Testing for tensile, yield and elongation shall be done in accordance with ASTM E8
   4. Sizes 12" and smaller must be capable of working on Cast/Grey Iron or Ductile Iron Class A, B, C and D without changing either top or bottom portion of split valve body
   5. 250 psi maximum working pressure. The pressure rating markings must be cast into the body of the insert valve.
   6. After the installation of the insert valve body on to the existing pipe, a pressure test of 1.1 times that of the contents shall be sustained for 15 minutes. Once the pressure test is affectively achieved, the insert valve body must not be moved in accordance with AWWA Standards. If the insert valve is moved the pressure test must be completed again. The insert valve must not be moved or re-positioned once the pressure test is achieved.

E. Resilient Wedge Gate Assembly:
   1. The construction of the resilient wedge shall comply with AWWA C509 requirements
2. The ductile iron wedge shall be fully encapsulated with EPDM rubber by a high pressure and high temperature compression or injection mold process
3. The resilient wedge shall seat on the valve body and not on the pipe to obtain the optimum seating and flow control results. The resilient wedge shall be totally independent of the carrier pipe.
4. The resilient wedge shall not come into contact with the carrier pipe or depend on the carrier pipe to create a seal
5. Pressure equalization on the down or upstream side of the closed wedge shall not be necessary to open the valve
6. The wedge shall be symmetrical and seal equally well with flow in either direction
7. The resilient wedge must ride inside the body channels to maintain wedge alignment throughout its travel to achieve maximum fluid control regardless of high or low flow pressure or velocity
8. The resilient wedge must have more support than the operating stem as the resilient wedge enters and exits the water (fluid) way

F. Fusion-Bonded Epoxy:
1. The insert valve is fully epoxy coated on the interior and the exterior. The fusion-bonded coating is applied prior to assembly so that even the bolt holes and body-to-bonnet flange surfaces are fully epoxy coated
2. Valve shall be coated with a minimum of 8 mils epoxy in compliance with AWWA C550 and certified to ANSI/NSF-61

G. Gaskets and Triple O-Ring Stem Seals:
1. This insert valve features triple O-Ring stem seals. One O-Ring is located above, and two O-Rings are located below the thrust collar.
2. The lower two O-Rings provide a permanently sealed lubrication chamber that will make the valve easier to operate over a longer period of time. The upper O-Ring ensures that sand, dirt or grit cannot enter the valve to cause damage to the lower O-Rings. This is especially important for buried and sewage service applications.
3. Side flange seals shall be of the O-Ring type of either round, oval, or rectangular cross-sectional shape

H. Valve Stem & Thrust Washers:
1. The gate valve stem and wedge nut shall be copper alloy in accordance with AWWA C515
2. The NRS stem must have an integral thrust collar in accordance with AWWA C515. Two-piece stem collars are not acceptable. The wedge nut shall be independent of the wedge and held in place on three sides by the wedge to prevent possible misalignment.
3. Two thrust washers are used. One is located above, and one is located below the stem thrust collar. Two thrust washers ensure easy operation at all times.
4. NRS with AWWA standard turns.
5. Operated by 2” square wrench nut according to ASTM A126 CL.B – open counter-clockwise.

I. Hardware:
1. Bolting materials shall develop the physical strength requirements of ASTM A307 with dimensions conforming to ANSI B18.2.1.

J. Extended Life Value:
1. The stuffing box, operating stem and resilient wedge (complete bonnet and all moving parts) shall be removable, repairable and or replaceable under pressure. In other words, even while the valve is fully pressurized in the system all moving components can be removed under pressure. In the event the valve stem is broken or damaged the bonnet can be removed under pressure.
2. Internal pressure equalization system assures the safe entry and removal of the valve bonnet during initial installation as well as future maintenance

K. Split Restraint Devices:
1. Shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of ANSI/AWWA C110/A21.10
2. The devices shall have a working pressure rating of 350 psi for 4-12 inch. Ratings are for water pressure and must include a minimum safety factor of 2 to 1 in all sizes
3. Chemical and modularity tests shall be performed as recommended by the Ductile iron Society, on a per ladle basis. Three test bars shall be incrementally poured per production shift as per U.L. specifications and ASTM A536. Testing for tensile, yield and elongation shall be done in accordance with ASTM E8.

4. Gland body wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536

5. Mechanical joint restraint shall require conventional tools and installation procedures per AWWA C600, while retaining full mechanical joint deflection during assembly as well as allowing joint deflection after assembly.

6. Proper actuation of the gripping wedges shall be ensured with torque limiting twist off nuts. Set screw pressure point type hardware shall not be used.

7. Restraint devices shall be listed by Underwriters Laboratories and Approved by Factory Mutual (3” through 12” inch size)

2.17 AIR RELEASE AND VACUUM BREAKER COMBINATION

A. Manufacturers:
   1. Vent-o-mat "RBX"
   2. GA "Figure CAV"
   3. Val-Matic "200C Series"
   4. APCO "140C Series"
   5. Or accepted substitution

B. Provide combination air release and vacuum breaker valves as indicated on Drawings
   1. Provide integral type that functions as both an air release and a vacuum breaker valve
   2. Provide a shutoff valve
      a. 2” and smaller valve size: ball valve
      b. Larger than 2” valve size: gate valve

2.18 RESTRAINED COUPLING ADAPTER

A. Manufacturers:
   1. JCM Industries
   2. Romac
   3. Or accepted substitution

B. General:
   1. Must meet or exceed AWWA C219
   2. Used to transition between dissimilar pipe materials in 3” to 12” as indicated on Drawings
   3. Rated for 250 psi working pressure
   4. Contractor to verify pipe material and diameter of all existing distribution pipelines

C. Sleeve and Flanges:
   1. Ductile iron per ASTM A536

D. Gasket:
   1. Nitrile Butadiene Rubber (NBR, Buna-N) per ASTM D2000
   2. Gasket temperature range -40°F to 212°F (-40°C to 100°C)
   3. Gasket suitable for water, salt solutions, mild acids, bases, and sewage

E. Bolts:
   1. 5/8” corrosion resistant, high strength low alloy oval neck track head bolts per ASTM A242 / ANSI 21.11 / AWWA C111 and heavy hex nuts per A563 or equal.
   2. Optional hardware: Stainless Steel 18-8 Type 304 or 316, Epoxy Coated Alloy Hardware, Powercron 590-534 black cationic electrocoat

F. Finish:
   1. Corrosion resistant shop coat paint primer
   2. Optional fusion applied epoxy coating per ANSI/AWWA C213
2.19 LINE STOPS

A. Manufacturers:
   1. Hydra-Stop, Hydra-Stopper
   2. JCM Industries
   3. Or accepted substitution

B. Nominal Size: 18-inch

C. Body: Carbon Steel in accordance with ASTM A36

D. Flange: Class D Carbon Steel in accordance with AWWA C207, recessed for tapping valve

E. Cover Flange: Cast Steel

F. Bolts: Stainless Steel, Type 304

G. Finish: Corrosion resistant primer and epoxy coating

2.20 BLOW-OFF DRAIN

A. Provide blow-off drains where indicated on the Drawings as shown on Details

2.21 FIRE HYDRANT

A. Fire hydrants to be provided for installation where indicated on the Drawings

B. Manufacturers:
   1. American AVK
   2. Kennedy Valve
   3. Or accepted substitution

C. General
   1. Fire hydrants shall meet or exceed AWWA C502; latest revision
   2. Hydrants shall be manufactured and tested in ISO 9001 certified facility
   3. Fire hydrants shall be rated for a working pressure of 250 psi
   4. A Higbee cut (blunt start) will be provided on the lead thread of the outlet nozzles, nozzle caps, seat ring, drain ring, and thrust nut.
   5. Fire hydrants shall be of the compression type, opening against system pressure and closing with system pressure

D. Main Valves and Drain
   1. The main valve and drain shall be of one piece construction and completely encapsulated with EPDM.
   2. Fire hydrants shall have a minimum 5-1/4 main valve opening.
   3. Fire hydrants shall open left and be clearly marked.
   4. The EPDM shall be permanently vulcanized to the main valve.
   5. The main valve shall provide complete closing of the drains after 4 to 5 turns.
   6. During initial stages of opening, the drains shall momentarily flush outward to remove any debris in the drain ports, in order to provide complete draining upon closing of the hydrant main valve.
   7. The drain ring assembly shall be replaceable without removing the hydrant from the connecting pipe or having to dig.
   8. Valve facings shall be of nontoxic materials suitable for potable water service.

E. Stems
   1. Upper hydrant stems shall be made of stainless steel
   2. Hydrant shall have one breakaway flange and stem coupling located 3-inches above finished grade.

F. Operating Nut
1. Operating nuts shall be one-piece bronze design with upper and lower anti-friction washers for ease of operation.
2. A protective weather shield shall be installed over the operating nut.
3. Operating nut shall be 1-1/2 inch and pentagon shape

G. Nozzles
1. Pumper nozzles shall be 4-1/2 inch NH / NST threaded.
2. Fire hydrants shall have two 2-1/2 inch hose connection outlets NH/NST threaded.
3. Nozzles shall be of the 1/4 turn bayonet lug style, secured with a stainless steel locking screw.
4. Caps shall have 1-1/2 inch pentagon shape nuts.
5. Nozzle caps shall be chained to hydrant.

H. Lubrication
1. A lubrication port shall be provided for application of lubricant without disassembly of the bonnet section.
2. The reservoir shall be filled with NSF/FDA approved food grade grease or oil at the manufacture's facility.
3. Valve stem seals shall be an o-ring type with not less than two o-rings below the thrust nut and two o-rings above the thrust nut.
4. O-ring and gaskets shall be made of an NBR rubber to help prevent the effects of permeation.

I. Protective Coatings
1. All ferrous parts except the lower barrel and those parts made of stainless steel shall be fusion bonded epoxy coated yellow
2. All epoxy coatings shall meet the requirements of ANSI/AWWA C550 (latest edition).
3. The lower barrel shall be bitumen coated both internally and externally.
4. A bury line shall be marked on the lower barrel below the break flange to indicate proper installation depth. Bury depth will be clearly stenciled on the standpipe section.
5. Shop paint exterior of hydrants red

J. Shoe
1. End connections shall be 6 inch mechanical joint unless specified
2. Mechanical joints shall comply with AWWA C111

K. Break Flange and Couplings
1. All fire hydrants shall be of the traffic Breakaway type and allow 360-degree rotation of the fire hydrant to position the pumper nozzle in the desired direction.
2. The break flange segments shall be located under the upper barrel flange to prevent the segments from falling into the lower barrel when the hydrant is struck.

L. Warranty
1. All fire hydrants shall be covered by a manufactured warranty for a minimum of 10 years for defects

M. Hydrant Gravel: Hydrant gravel shall be well graded crushed stone or gravel, conforming to AASHTO #67 gradation as listed below:

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<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
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<td>100</td>
</tr>
<tr>
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<td>3/8&quot;</td>
<td>20-55</td>
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<td>0-10</td>
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<td>No. 8</td>
<td>0-5</td>
</tr>
</tbody>
</table>

2.22 BACKFLOW PREVENTION

A. Manufacturers:
1. Mueller
2. Ford
3. Or accepted substitution

B. Installed upstream of flow meter
C. Top entry vertical dual check valve
D. Inlet: Meter swivel nut
E. Outlet: Mueller Pack Joint Connection for CTS OD tubing

2.23 CORROSION CONTROL

A. Shop paint all ferrous metal surfaces of valves and accessories, both interior and exterior for corrosion protection, epoxy interior coating for potable water contact.

B. Manufacturer's standard paint will be acceptable if it is functionally equivalent and compatible with specified field coatings

C. Exterior bituminous coating or asphalt varnish: Manufacturer's Standard epoxy coal tar

D. Ductile-iron Pipe and Fittings Shop lining: Cement-lined, AWWA C104/C205

E. Rust inhibitive primer: Tnemec "Series 77H Chem-Prime" or accepted substitution

F. Rust preventative compound: Houghton "Rust Veto 344", Rust-Oleum "R-9", or accepted substitution

2.24 BEDDING

A. Bedding: As specified in Section 31 00 00

2.25 ACCESSORIES – MISCELLANEOUS

A. Extension stems
   1. For valve installations with operating nuts over 5 five below grade, extend stem to 4.5 feet of final grade. Provide spacers to center stem in valve box.

B. Valve boxes for all buried valves, depth as required for valve
   1. Three piece cast iron (complying with ASTM A48, Class 20A) adjustable screw type, 5.25-inch diameter, minimum thickness of 3/16 inch.
   2. Box, cover, and base coated by dipping in asphalt varnish.
   3. Cover marked with word, "WATER."
   4. Provide threaded top section to permit 6-inch adjustment above finish grade.
   5. Series 6860 with #160 oval base as manufactured by Tyler Pipe Company or accepted substitution.

C. Concrete for Thrust Blocks: constructed of “Class B” Concrete as defined by CDOT Construction Specifications with maximum water to cement ratio of 0.63 by weight and 28-day compressive strength of 3,000 psi

D. Anchorages: Provide anchorages for tees, wyes, crosses, plugs, caps, bends, valves and hydrants. After installation, apply full coat of asphalt or other acceptable corrosion-retarding material to surfaces of ferrous anchorages.
   1. Clamps, straps and washers: Steel, ASTM A506
   2. Rods: Steel, ASTM A575
   3. Rod Couplings: Malleable-iron, ASTM A197
   4. Bolts: Steel, ASTM A307
   5. Cast-Iron Washers: Gray-iron, ASTM A126
2.26 DISINFECTION CHEMICALS

A. Calcium and sodium hypochlorite shall conform to AWWA B300 and B301

B. Store hypochlorite in a cool, dark place away from flammable materials

2.27 PRECAST CONCRETE VAULT

A. Manufacturers:
   1. Oldcastle Precast
   2. Front Range Precast Concrete
   3. Or accepted substitution

B. Materials
   1. Reinforcement
      a. Reinforcing Steel: ASTM A615 Grade 60
      b. Welded Wire Fabric: ASTM A185
   2. Concrete:
      a. Cement: ASTM C150, Portland Cement, Type II
      b. Aggregates: ASTM C33, free of deleterious substances
      c. Minimum compressive strength: ASTM C39, 4500 psi minimum at 28 days
   3. Precast Sections
      a. Specification: ASTM C1227
      b. Minimum wall thickness: 6 inch
      c. Grade rings as required
   4. Gaskets: ASTM C923
      a. Mastic: FS SS-S-210A, "RAM-NEK" or accepted substitution
      b. Rubber: Neoprene, 40+5 hardness when measured by ASTM D2240, Type A durometer
   5. Castings: ASTM A48 with asphalt varnish coating hot dip applied at foundry, 6 mils thick
   6. Manhole Steps: Steel bar, 1/2 inch Grade 60, drop-front type, with polypropylene coating applied by manufacturer, Type MA Industries, Inc. "PS2-PF" or accepted substitution
   7. Inlet Gratings and Manhole Ring and Cover
      a. Cast iron, heavy duty traffic type, ASTM A48, Class 30B. Grind bearing surfaces to ensure flat, true surfaces
      b. Covers to seat at all points on ring
   8. Pipe Penetrations:
      a. Cast-a-Seal gasket
      b. Link-Seal
      c. Or accepted substitution
   9. Manhole Height Adjustment: Use precast concrete grade rings
   10. Rock Subbase: 1-1/2 inch minus, well-graded gravel over compacted subgrade
   11. Water: Clean and free of deleterious substances

C. Fabrication
   1. Vault Section
      a. Precast concrete dimensions as shown on plans
      b. Precast lid: Same or greater reinforcement and wall thickness with capability for H20 loading
      c. Joints: Shiplap or tongue and groove with double mastic gaskets, each joint to set equally and tightly
      d. Access opening: Minimum 24 clear
      e. Pipe connection: As indicated on Drawings
      f. Pipe knockout: As indicated on Drawings
   2. Grating and Metal Frame: As specified on Drawings
PART 3  EXECUTION

3.1 EXAMINATION

A. Verify existing conditions under provisions of Division 1 Specifications
B. Verify locations and inverts or tops of pipe for connections to existing system as well as crossings with other utilities as indicated on the drawings. Report any discrepancies to Engineer
C. Carefully examine pipe and fittings for cracks, damage to linings, and other defects prior to installation
D. Remove all defective piping from site and replace
E. Examine areas for weak or structural defects or deviations beyond allowable tolerances for piping clearances that adversely affect excavation and quality of Work
F. Start installation only when conditions are satisfactory
G. Verify items provided by other sections of Work are properly sized and located
H. Verify that built-in items are in proper location, ready for roughing into Work
I. Verify excavation for vault is correct

3.2 PERFORMANCE - GENERAL

A. Perform work in a safe and proper manner with appropriate precautions against hazard
B. Provide adequate working space and clearances for work performed within excavations and for installation and removal of utilities
C. Contain all construction activity on the designated site and within the limits of work. Cost of restoration of site will be the responsibility of the Contractor
D. Contractor to verify quantities to perform all earthwork required according to Drawings, including but not limited to, additional import or export required to handle compaction, pavement subgrade preparation, and pipe bedding
E. Contractor shall take precautions to limit the removal of or damage to existing pavements, multi-use paths sidewalks, curbs, lawns, shrubbery, trees, hedges, walls, fences, buildings, or other existing improvements to the least practicable amounts and shall replace or restore such improvements to their original location and condition after the excavation has been backfilled and compacted

3.3 PROTECTION OF EXISTING UTILITIES AND STRUCTURES

A. Excavation and backfill operations shall be performed in such a manner to prevent cave-ins of excavations or the undermining, damage or disturbing of existing utilities and structures or of new work
B. Backfill shall be placed and compacted so as to prevent future settlement or damage to existing utilities and structures and new work
C. Any excavations improperly backfilled or where settlement occurs shall be reopened to the depth required then refilled with approved materials and compacted, and the surface restored to the required grade and condition, at no additional costs to the Owner
D. Any damage due to excavation, backfilling, or settlement of the backfill, or injury to persons or damage to property occurring as a result of such damage shall be the responsibility of the Contractor. All costs to
repair such damage, in a manner satisfactory to the Engineer, shall be borne by the Contractor at no additional expense to the Owner

3.4 SITE PREPARATION

A. Clear all site areas within the limits of work of grasses, roots, brush, and other objectionable material and debris

B. Remove all waste materials from site and dispose. Stockpile all acceptable grubbings for reuse in revegetation areas.

C. Remove debris including all demolished trees, underbrush, stumps, roots and other combustible materials from site and dispose of off-site; on-site burning is not permitted

3.5 DEWATERING

A. Comply with CDPHE Dewatering Requirements

B. Dewatering discharge to surface waterways requires CDPHE dewatering permit. Contractor must obtain dewatering permit and comply with discharge requirements therein, if necessary

3.6 PIPE PREPARATION

A. Ream pipe and tube ends and remove burrs

B. Remove scale and dirt, on inside and outside, before assembly

C. Cut ends of metallic pipe, recoat with coating approved for potable water service and compatible with manufacturer's coatings.

3.7 PRECAST CONCRETE VAULT PREPARATION

A. Verify items provided by other section of Work are properly sized and located

B. Verify that built-in items are in proper location, ready for roughing into Work

C. Verify excavation for manholes is correct

D. Excavation, Backfill, Subgrade Compaction: Refer to Section 31 00 00 for requirements

E. Rock Subbase
   1. Remove water and place 6-inch minimum depth
   2. Vibrate for compaction
   3. Level top to accept precast sections with uniform bearing all around
   4. If material below vault is unsuitable, excavate as directed by the Engineer and backfill to grade with 1-1/2 inch minus rock and compact

3.8 PLACING PRECAST SECTIONS

A. Thoroughly clean joints of sections to place gasket material

B. Place gasket material on base or lower section to ensure watertight fit between lower precast section and upper precast section

C. Fill inside and outside of joint completely with non-shrink grout and trowel smooth

D. Cure non-shrink grout using approved methods as recommended by manufacturer
3.9 PREFORMED GASKETS

A. Remove and replace vault sections which have chipped or cracked joints
B. Thoroughly clean section joints
C. Install gasket in conformance with manufacturer's recommendations
D. Only use primer furnished by gasket manufacturer

3.10 BEDDING

A. Comply with Town of Berthoud standards and specifications
B. Excavate pipe trench in accordance with Section 31 00 00 for work of this Section. Do not disturb trench bottom during excavation. Hand trim excavation for accurate placement of pipe to elevations indicated.
C. Place bedding material in accordance with Section 31 00 00 at trench bottom, level fill materials in one continuous layer not exceeding 6 inches compacted depth, compact to 95 percent. Protect from lateral displacement by placing embedment evenly on both sides of pipe
D. Provide dewatering and backfill trench in accordance with Section 31 00 00

3.11 PIPE INSTALLATION

A. Comply with Town of Berthoud standards and specifications. Use the manufacturer's recommendations if the Town of Berthoud standards do not specifically apply.
B. Install PVC Pipe in accordance with AWWA M23 and AWWA C605
C. Install Ductile Iron Pipe in accordance with AWWA C600
D. Install Ductile Iron Fittings in accordance with AWWA M41
E. Route pipe as indicated on the Drawings
F. The inside of all pipe, valves, and fittings shall be smooth, clean, and free from blisters, loose mill scale, sand, and dirt when connected
G. Install as specified or in accordance with the manufacturer's recommendations
H. Cutting Pipe
   1. Cut pipe to measurement taken at the site, not from the drawings
   2. Cut pipe neatly without damage to pipe
   3. Cut smooth, straight, and at right angles to pipe axis
   4. Dress and bevel end of cut pipe to remove roughness and sharp corners
   5. Cut pipe with saw or abrasive wheel
   6. Follow state and federal safety regulations pertaining to cutting asbestos concrete pipe as necessary
I. Provide an isolation or shutoff valve and union at the water connections to each fixture and unit of equipment, whether shown on the drawings or not
J. Install pipe to indicated elevations. Maintain minimum 4.0 feet depth of ground cover and maintain minimum grade for drainage. Establish elevations of buried piping to ensure minimum cover is achieved. Maximum depth of 7.0 feet is allowed to avoid a local high point unless shown otherwise on the plans. Add additional soil in areas of future fill to provide minimal cover at all times. Report any variations from plan to Owner and Engineer
1. Provide air release valve at all high points and blow-offs or hydrant at all low points. Coordinate locations and details with Engineer.

2. Where minimum depth cannot be maintained, provide a minimum of 2 inch of specified insulation board per 1 foot of cover not provided. Contractor must have Owner and Engineer approval prior to installation.
   a. Place insulation board over bedding material for the width of the trench

K. Install pipe to allow for expansion and contraction without stressing pipe or joints

L. Protect from lateral displacement by placing embedment evenly on both sides of pipe

M. Do not lay pipe in water. Maintain groundwater level a minimum of 12 inches below pipe to be installed. Do not lay pipe under unsuitable weather or trench conditions

N. Make changes in horizontal, vertical, and curved alignment shown on drawings by using joint deflections in the amount permissible by manufacturer and shown on drawings

O. Do not bend pipe

P. Deflect pipe at joints

Q. Do not deflect PVC pipe at connection to ductile iron fittings

R. Form and place concrete for thrust blocks at each elbow or change of direction of pipe main as indicated on Drawings

S. Utility crossings
   1. Whenever possible, lay water mains over sanitary and storm sewers to provide vertical separation of at least 18-inch between invert of water main and crown of sewer
   2. If standard crossing detail is not available and above separation cannot be met, provide one continuous length of watertight sewer pipe 20' long centered on water main with joints between different pipes encased in 6-inch minimum of concrete and extending 6-inch either side of joint or encase sewer pipe in 6-inch of concrete completely around pipe, for not less than 10’ either side of water main
   3. Water Mains Passing Under Sanitary Sewers: If vertical separation is less than 18-inch, provide structural support for sewer. Provide concrete encasement where water lines pass under sanitary sewer line. Reference detail shown on Drawings

T. Maintain a minimum 10 feet of horizontal separation and 18 inches of vertical separation between water main and storm or sanitary sewer lines in accordance with the CDPHE
   1. Provide concrete encasement if these clearances cannot be achieved and when water line is below sanitary sewer line

U. Tracer wire and marker tape
   1. Install tracer wire continuous over top of pipe
   2. Install tracer wire test stations at maximum 500 LF of water line per Town of Berthoud requirements. Locate test station at fire hydrants, gate valves, or special test station locations in a valve box
   3. Terminate tracer wire following drawing details
   4. Tape tracer wire to top of pipe using PVC tape every 4 feet along the pipe, and on each side of fitting a. Tape: minimum 2 inches wide and wrapping full circumference of pipe
   5. Install identification /warning marker tape in fill area of trench above all water lines

V. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system

W. Install access fittings to permit disinfection of water system, subject to approval by Engineer

X. Backfill trench in accordance to specifications herein
Y. Protect pipe from floatation or movement until completely backfilled and put into service

3.12 WATER MAIN CONNECTIONS
A. Comply with Town of Berthoud standards and specifications. Coordinate with Town of Berthoud and fire department representatives for any impacts to the existing water system and provide advanced notice to impacted properties if applicable.
B. Connect to water main per plans and referenced standards or details.

3.13 JOINTS
A. Make pipe joints carefully and neatly
B. Connect piping in accordance with manufacturer’s recommendations
C. Push-on joints
   1. Lay pipe with bell ends facing the direction of laying except when Engineer authorizes reverse laying
   2. Assembly of PVC plain end into bell: follow PVC pipe manufacturer’s recommendation
   3. For PVC pipe, Contractor to ensure that pipe is not inserted into the bell ends beyond the push line
      a. Utilize EBAA Mega-Stop bell protection, or approved substitution, if necessary, to ensure previously laid pipe joints are not impacted by ongoing installation
   4. Lubricate joint surfaces immediately before completing the joint
   5. Bevel spigot ends of field cut piping
   6. Groove spigot ends of field cut restrained joint piping if required by joint system
   7. Install restrained joints following manufacturer’s recommendations
D. Mechanical joints
   1. Before assembling joint, clean both bell and plain end of rust and foreign matter
   2. Assemble joint following AWWA C111, C600, C605 and as specified
   3. Lubricate gasket and install in accordance with manufacturer’s instructions
   4. If an effective seal is not obtained, disassemble joint, clean thoroughly, and reassemble
   5. Do not over tighten bolts to compensate for poor installation
   6. Carefully align holes in mechanical joints with restraint device to permit installation of the harness bolts
   7. Install mechanical joint pieces so the mechanical joint holes straddle the top centerline for horizontal piping, or the side centerline for vertical piping

3.14 PROTECTIVE COATING
A. Provide polyethylene tube encasement on all buried ductile iron fittings, valves, and fire hydrant extensions
   1. Encase ductile iron fittings and valves in polyethylene per AWWA C105, Method A, secured with polyethylene compatible adhesive tape. Overlap polyethylene onto PVC pipe a minimum of 6 inches
   2. Before backfilling, inspect polyethylene for rips, punctures and other damage and repair following AWWA C105
B. Coat exposed ferrous metal surfaces of joints, couplings, and uncoated steel with primer and tape coating system after installation. Do not coat stainless steel or high strength low alloy steel nuts and bolts
   1. Surface Preparation: Clean surfaces of rust, scale, soil, mud, oil, grease, and other contaminants by hand or power tool following SSPC-SP2 or SP3 and other appropriate means as recommended by coating manufacturer Remove excess moisture and provide surface dryness as recommended by coating manufacturer
   2. Application: Apply primer in uniform manner to clean and dry surfaces following coating manufacturer’s recommendations
      a. Fill complex and irregular surfaces with appropriate mastic or filler tape to eliminate bridging; then apply tape/wrap to primed and filled surfaces following coating manufacturer’s recommendations.
      b. When coating restraining rods or strapping, apply tape wrap longitudinally
      c. Where metal being coated enters concrete, overlap coating onto concrete by minimum of 2 inches after placement of concrete
3. Inspection: After field coating of specified items, conduct visual inspection to verify complete coverage has been accomplished.
   a. Repair damaged or incompletely coated surfaces following coating manufacturer's recommendations

C. Metal Surfaces not Protected by Poly Wrap
   1. Coat all steel clamp rods, bolts, and other metal accessories used in tapping saddles, anchorages, cut ends of pipe, follower rings and bolts or joint harnesses subject to submergence or contract with the earth and not concrete encased, but including pipe fittings and bolts in polyethylene tube protection
   2. Apply 2 coats of coal tar paint to clean, dry metal surfaces, allow first coat to dry before applying second coat

D. Metal Harness Rods
   1. Provide field applied primer and Polyken tape wrap

3.15 CONCRETE ENCASEMENT

A. Provide where indicated on the Drawings

B. Comply with Town of Berthoud standards and specifications.

C. Suitably support and block pipe and anchor against flotation

3.16 CATHODIC PROTECTION

A. Anode installation
   1. Fasten anode lead wire to anode by silver solder. Install a minimum of 25 feet of wire. No splicing will be permitted. Insulate connection to a minimum of 600 volts, overlapping lead wire insulation by ½ inch minimum.
   2. Provide bonding between pipes and fittings of similar metals to ensure components are electrically continuous.
   3. Weld test wires to pipe and terminate at appropriate test station. Both test wires and anode lead wires shall terminate at the cathodic protection test station. No less than two wires shall be installed to the pipe at each site for redundancy. Wires shall be installed in Schedule 80 PVC electrical conduit equipped with duct seal. Install plastic warning tape 12 inches above pipe.
   4. Test stations shall be located at the following locations affected or installed during the project:
      a. At each end of casing under the roadway.
      b. At each inaccessible insulating pipe joint.
      c. At intervals not to exceed 1,000 feet.
   5. Provide marker posts for test stations located outside of vehicular traffic areas.
   6. Restore corrosion protective coatings and wraps damaged during installation, including those on existing pipes.
   7. Install wire identification tags.

B. Anode Activation and Field Quality Control
   1. A NACE certified Level 2 Cathodic Protection Technician, or equivalent, shall perform all inspection testing under the direct supervision of the Corrosion Engineer.
   2. Measure and record the Native Potentials at all cathodic protection test stations.
   3. Verify the potentials of all magnesium anodes prior to connecting anodes to pipes.
   4. Appropriately connect wires at the test station.
   5. Record and explicitly state the shunt rating at each test station.
   6. Re-measure potentials at all test stations at last two weeks following initial activation.
   7. All test results and records of Native Potentials shall be included in a report describing the cathodic protection system, description of test methods, an analysis of the test data, and conclusions about the systems effectiveness. The report shall be submitted to the Engineer and Owner.
   8. Any deficiencies following testing or determined non-compliance with NACE SP0169, shall be communicated in writing to the Engineer and Owner. Any corrections will be the responsibility of the Contractor at no additional cost to the Owner.
3.17 VALVES AND HYDRANTS INSTALLATION

A. Carefully inspect valve before installation. Clean interior. Operate valve to determine parts in proper working order, with valves seating and drain valve operating properly. Set plumb and center stem in valve box and securely brace into place. Comply with AWWA C600 and referenced standards.

B. Center and plumb valve box over valve. Set box cover flush with finished grade.
   1. Backfill and compact under and around valve boxes to ensure no vertical loads are transmitted to valve operators or bonnets.

C. Comply with AWWA M17 for fire hydrant installation. Install with gate valve and provisions for drainage.

D. Install valves, hydrants, and accessories in accordance with the manufacturer's recommendations and in accordance with referenced standards and specifications.

E. Hydrants and valves to be set plumb on solid bearing surface.

F. Locate hydrant flange a minimum of 3” and maximum 6” above adjacent finished grade or flush with the adjacent top of curb. Contractor to verify final grade or adjust flange height upon the completion of final grading.

G. Drainage shall be provided at the base of the hydrant by placing rock from the bottom of the trench to at least 12 inches above the barrel flange of the hydrant and to a distance of 12 inches around the elbow. The minimum distance from the bottom of the trench to the bottom of the hydrant elbow shall be 6 inches. The minimum amount of rock placed shall be 1/3 cubic yard.

3.18 VALVE INSTALLATION

A. Comply with Town of Berthoud standards and specifications.

B. Carefully inspect valve before installation. Clean interior. Operate valve to determine parts in proper working order, with valves seating and drain valve operating properly. Set plumb and center stem in valve box and securely brace into place. Comply with AWWA C600 and referenced standards.

C. Provide concrete collar for installations within landscaped areas.

D. Protect valve box and cover during paving operations and clean any excess concrete, or asphalt, or road base from valve box and cover to ensure visibility and proper operation.

3.19 INSERTION VALVE INSTALLATION

A. Install according to Manufacturer's suggested procedures.
   1. Clean the area of the pipeline that is to receive the insert valve.
   2. Prepare the insert valve for assembly onto the pipeline per Manufacturer's recommendations.
   3. Install the two insert valve body halves on the pipeline.
   4. Bolt two body halves of insert valve together. Tighten bolts per Manufacturer's recommendations.
   5. After body bolts have been tightened, confirm that the insert valve is level.
   6. Install mechanical joint gaskets to insert valve and complete assembly using split mechanical joint restraints.
   7. Attach temporary insertion valve. A test port shall be attached and the assembly should be pressure tested.
   8. Prepare tapping machine for mounting to temporary valve.
   9. Tapping machine shall be mounted to the temporary isolation valve with chip flushing valve attached.
   10. After completing the tap, close temporary isolation valve.
   11. Remove tapping machine and cut out pipeline section.
   12. Prepare insertion valve bonnet for live line insertion and attach to valve insertion tool per Manufacturer's recommendations.
14. Open temporary isolation valve and advance travel of the bonnet to the body of the insert valve
15. Install six set pins to secure bonnet to insert valve body
16. Once set pins are in place, release the bonnet from the insertion tool
17. Use insertion tool blow off valve to release water with insertion tool housing and remove insertion tool from temporary insulation valve
18. Remove temporary isolation valve
19. Install O-Ring between valve body and bonnet to seal connection

3.20 TAPPING

A. Tapping shall be performed using standard tapping saddles designed for use on PVC piping in accordance with AWWA C605. Tapping shall be performed only with use of tap saddles or sleeves. NO DIRECT TAPPING WILL BE PERMITTED. Tapping shall be performed in accordance with the applicable sections for saddle tapping as per "Uni-Pub-8: Tapping Guide for PVC Pressure Pipe by Uni-Bell PVC Pipe Association"

B. All connections requiring a larger diameter than that recommended by the pipe supplier, should be made with a pipe connection as specified and indicated on the drawings.

C. Equipment used for tapping shall be made specifically for tapping PVC pipe:
   1. Tapping bits shall be slotted "shell" style cutters, specifically made for PVC pipe. ‘Hole saws’ made for cutting wood, steel, ductile iron, or other materials are strictly prohibited

3.21 WATER SERVICES

A. Water services are to be connected to the new water main per the Contract Drawings and Town of Berthoud Standards

B. Water services are to be tapped per the Contract Drawings. Direct taps are not permitted.

3.22 THRUST BLOCKS

A. Installation:
   1. Thrust blocks shall be constructed at bends and fittings that require support due to unbalanced line thrust. Care shall be taken to ensure that outlets, cover bolts, nuts, clamps, and other fittings are accessible. A bond breaker shall be placed between the pipe and the thrust block to aid in future removal. If a large thrust block is to be placed, it shall be separated into sections by a suitable material. Bearing surface areas are minimum areas to bear against the undisturbed trench wall. If the soil bearing capacity is insufficient to provide adequate support based on minimum bearing areas established by Drawing Details, then the minimum bearing area shall be increased to a size that shall ensure support restraint. In every instance, the thrust block shall bear against undisturbed earth
   2. Before placing concrete, equipment used in the mixing and transport shall be cleaned. Debris, water, or ice shall be removed from the area to be occupied by concrete. Concrete shall not be placed on frozen subgrade. Concrete shall be placed only in the presence of the Owner or Engineer unless inspection is waived prior to the placement

B. Formwork for Thrust blocks:
   1. Forming for concrete thrust blocks and anchors shall be done by bulkheading around the shape of the thrust block or anchor with wood, burlap sacks, or reinforced paper sacks that are filled with sand or earth. Sacks shall be constructed of a size easily handled when full and left in place in the trench. Wood forms shall be removed before backfilling.
   2. Horizontal struts or braces required for trench shoring shall not remain in concrete thrust blocks. Prior to placing concrete, the forms and ditch bank will be inspected and approved by Owner or Engineer
   3. When concrete is deposited against the ground without the use of forms, the ground shall be thoroughly moistened or other provisions made to prevent the ground from drawing water in from the concrete
C. Thrust block Curing Time:
   1. Newly placed concrete shall be allowed to set undisturbed for a minimum of 24 hours

D. Compaction of Fill Over Thrust blocks
   1. Backfill may be placed over thrust blocks once the surface has set sufficiently and they are able to resist the weight of the backfill. However, tamping or compacting shall not be allowed above the thrust block for a minimum of 24 hours after placement

E. Hydrostatic testing shall not be conducted until thrust blocks have fully cured, a minimum of 7 days

3.23 ABANDONMENT

A. Cap ends of main as shown. Place required concrete blocking as shown on drawing details

B. Where mains are to be abandoned and removed to a fitting or valve, cut and plug main at fitting or valve
   1. When shown on drawings, remove fire hydrants and valves, including lead joint tees when encountered; salvage and deliver removed fire hydrants and valves to the Town of Berthoud
   2. Pipe, fittings, and other appurtenances that are removed, but are not required to be salvaged become property of Contractor
      a. Remove and dispose of offsite

3.24 ERECTION TOLERANCES

A. Establish invert elevations as shown on the drawings

B. Construct pipe within manufacturer’s tolerances of horizontal and vertical deflection. Refer to Town of Berthoud for allowable deflections at joints and fittings.

3.25 FIELD QUALITY CONTROL

A. Comply with Town of Berthoud standards and specifications. Test each line at the Contractor’s expense in the presence and to the satisfaction Town of Berthoud inspectors.

B. Field inspection and testing will be performed under provisions set forth by the referenced standards

C. Test each line at the Contractor’s expense in the presence and to the satisfaction of Owner or Engineer at a maximum of 1,000 foot intervals

D. Water Line Disinfection
   1. Comply with AWWA C651 and provide Engineer and Owner with results.
   2. Flush water lines prior to disinfection, except when tablet method is used. Acceptable chlorine disinfectants are calcium hypochlorite granules, sodium hypochlorite solutions, and calcium hypochlorite tablets.
   3. After the pipe is filled with water and chlorine, the chlorinated water shall be held in contact with the pipe for 24 hours. At the end of the 24 hour period, the water in the pipeline shall be tested by the local health authority having jurisdiction, or their designated representative, to ensure a residual chlorine content in compliance with Town of Berthoud requirements. The pipeline shall then be thoroughly flushed to remove the heavily chlorinated water. This activity requires a permit from the CDPHE WQCD prior to flushing. Comply with all provisions of the permit. Care shall be taken in flushing the pipeline to prevent property damage and danger to the public. Discharges of water from blowoff assemblies or other appurtenances shall be contained or discharged in a manner approved by Town of Berthoud and the CDPHE.
   4. For fire lines, flush piping complying with NFPA 24
   5. If water in pipe does not meet the governing agency requirements, repeat disinfection procedure until acceptable. Furnish copies of acceptance forms from governing agency to Owner and Engineer.

E. Valve Testing
   1. Conduct pressure and leakage tests on all newly installed valves
2. Furnish all necessary equipment and material and make all connections to the pipe, as required. The Engineer shall monitor the tests.

F. Hydrostatic Pressure Testing
1. Provide all necessary pumping equipment, piping connections, pressure gauges with maximum of 5 psi increments, and other required equipment, facilities, and materials.
2. Test only using potable water in conformance with [Town, City, District] standards.
3. If tests indicate work does not meet specified requirements, remove work, replace and retest at no cost to Owner.
4. Hydrostatic Test Conditions: At lowest point in the line or section under test, pressurize to 150 psi minimum. The pipeline shall be filled at a rate that does not create surges and does not exceed the rate at which air can be released.
5. While the test pressure is maintained, an examination shall be made of the pipeline and any leaks located and repaired. Pipe or fittings found to be faulty shall be removed and replaced. Leakage is not allowed through the bonnet of the line valve. A valve leaking through the bonnet may be repaired in place or removed and replaced. Cutting and replacement of pavement as well as excavation and backfilling may be necessary when locating and repairing leaks discovered during pressure testing.
6. After visible leaks are stopped, the full test pressure shall be maintained for 1 continuous hour. Allowable leakage for each section between line valves shall not exceed [Town, City, District] requirements.

G. PVC Water Pipe Continuity Testing
1. Test tracer wire for continuity, in the presence of Owner and Engineer, after backfill is complete and before Substantial Completion
2. Notify Owner and Engineer five working days in advance to schedule testing
3. Continuity test to consist of locating the PVC water pipe with an electronic-type pipe locator
4. If test is negative for continuity, repair or replace as necessary to achieve continuity

H. Bac-T Testing
1. After completion of water line disinfection as specified in Section 33 13 00, Contractor shall take Bac-T samples to ensure pipe has been properly disinfected and submit results to Engineer
2. If water line fails Bac-T sampling, any repeat disinfection and Bac-T testing will be at the Contractor’s expense
3. The Contractor shall receive Town of Berthoud approval before placing a water line in service

3.26 CLEANING
A. Verify that piping has been cleaned and inspected
B. Verify that piping has been successfully pressure tested and flushed
C. Perform scheduling and disinfection activity with start-up, testing, adjusting, demonstration procedures, including coordination with related systems

3.27 DISINFECTION
A. Provide and attach required equipment to perform the work of this Section
B. Tablet, continuous, or slug disinfection may be followed in accordance with AWWA C651
C. The preferred method is continuous disinfection, summarized as follows:
   1. Inject treatment disinfectant, free chlorine in liquid form into piping system to obtain 50 to 80 ppm residual
   2. Bleed water from outlets to ensure distribution and test for disinfectant residual
   3. Maintain disinfectant in system for 24 hours
   4. If final disinfectant residual tests less than 25 ppm, repeat treatment
   5. Flush, circulate and clean until residual equal to that of incoming potable water or 1.0 mg/L is achieved
D. Replace permanent system devices removed for disinfection
3.28 FINAL FLUSHING

A. Maintain a flushing velocity of 2.5 feet per second in piping

B. Collect chlorinated water for proper disposal and/or dechlorinate to less than 0.1 ppm free chlorine prior to discharge in accordance with State, County, and local regulations

3.29 DISINFECTION FIELD QUALITY CONTROL

A. After final flush, and before main or equipment is placed in service, collect water samples from representative points along the main and field test for chlorine residual

B. Chlorine residual shall be within 50 percent of the chlorine residual prevailing in the source

C. If initial disinfection fails to provide satisfactory samples, repeat disinfection until satisfactory samples have been obtained

3.30 DISINFECTION TESTING AND ACCEPTANCE

A. The Contractor will perform Bacteriological (Bac-T) sampling and testing after pipes have been disinfected and flushed as specified herein

B. If any portion of the piping or equipment or tanks fails Bac-T testing, the Contractor is responsible for repeating disinfection procedures until passing Bac-T test is obtained

3.31 FINAL ACCEPTANCE

A. Comply with Town of Berthoud standards and specifications for placing water line in service

B. The inside of all pipe, valves, and fittings shall be smooth, clean, and free from blisters, loose mill scale, sand, and dirt when connected.
   1. Wire brush, if necessary, wipe clean and keep joint contact surfaces clean until connection is complete

C. Drain all test water from the new pipe system prior to placing in service

D. Provide water tap locations shown on the Drawings

E. Provide operation and maintenance manuals for air and line valves and fire hydrants

F. Provide final reports to Engineer for:
   1. Bac-T results
   2. Residual chlorine tests
   3. Hydrostatic tests for each section or pipe
   4. Cathodic protection system test(s)
   5. Tracer wire continuity test

END OF SECTION
SECTION 33 33 00
SANITARY SEWERAGE UTILITIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Polyvinyl chloride (PVC) non-pressure pipe for gravity sanitary sewer with all jointing materials, fittings, and other appurtenances required for a complete installation

B. All precast manholes complete with steps, ring and cover as required

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):
   3. A185 – Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement
   4. A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
   5. A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
  10. C497 – Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile
  11. C913 – Standard Specification for Precast Concrete Water and Wastewater Structures
  13. C1227 – Standard Specification for Precast Concrete Septic Tanks
  16. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
  17. D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
  27. D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
  29. D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
34. F412 – Standard Terminology Relating to Plastic Piping Systems
35. F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
38. F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
39. F2164 – Standard Specification for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

B. American WaterWorks Association (AWWA):
2. C105 – Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems
7. C504 – Standard for Rubber-Seated Butterfly Valves
9. C600 – Standard for Installation of Ductile Iron Mains and Their Appurtenances
10. C900 – Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution
11. C905 – Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm), for Water Transmission and Distribution
12. M23 – PVC Pipe: Design and Installation

C. Colorado Department of Transportation (CDOT)

D. Occupational Safety and Health Administration (OSHA)

A. American Welding Society (AWS):
1. D1.1 – Structural Welding Code – Steel

B. National Association of Corrosion Engineers (NACE):
1. SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
2. SP0286 – Electrical Isolation of Cathodically Protected Pipelines

C. Plastics Pipe Institute (PPI):
1. TR-4 – HDB / HDS / SDB / PDB / MRS Ratings for Thermoplastic Piping Materials or Pipe
2. TR-33 – Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe
3. Handbook of Polyethylene Pipe
4. Polyethylene Piping Systems Field Manual for Municipal Water Applications
5. Material Handling Guide

1.3 SUBMITTALS

A. Submit under provisions of Division 1 Specifications

B. Shop Drawings: Provide piping layout and assembly drawings with fitting dimensions. Provide sufficient information to verify compliance with specifications

C. Product Data: Provide manufacturer's catalog information with dimensions, material and assembled weight.
1. Pipe materials
2. Special, fitting, and coupling details
3. Gasket materials
4. Valves
5. Laying and installation schedule
6. Specifications and data sheets
7. Affidavits of compliance for protective shop coatings and linings

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and applicable standards. Provide prior to shipment.

E. Test Reports: Submit reports of field exfiltration/infiltration, mandrel and lamp tests under provisions of Division 1 Specifications

F. TV Inspection Files: Submit videos and reports

1.4 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 1 Specifications

B. Accurately record actual locations of piping mains, valves, connections, invert elevations, and any mapped or unmapped utilities

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with Town of Berthoud and CDPHE Stormwater and/or Groundwater Discharge Permit, notes on the drawings and as specified herein.

B. Manufacturers shall be experienced in the design and manufacturing of materials specified herein for a minimum period of 5 years

C. All PVC pipe, regardless of diameter, shall be supplied by a single manufacturer

D. Perform Work in accordance with the Colorado Department of Public Health and Environment (CDPHE) and Town of Berthoud

E. Contractor shall conduct visual inspection before installation

F. Provide manufacturer’s name and pressure rating marked on piping and valves

G. Provide piping complete with all fittings, jointing materials, supports, joint restraint system, and necessary appurtenances for watertight, fully operational sewer lines

1.6 REGULATORY REQUIREMENTS

A. Conform to all municipal codes and ordinances, laws and regulations of Larimer County, Town of Berthoud, and CDPHE, the notes and details on the drawings and as specified herein, and CDPHE Stormwater Management and/or Construction Dewatering Permit

B. In case of apparent conflict, CDPHE requirements govern over these specifications

C. Contractor, not Owner, shall prepare, submit, pay, and otherwise obtain all necessary permits from all appropriate entities

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1 Specifications

B. During loading, transporting and unloading, exercise care to prevent damage to material
   1. Use nylon slings only
   2. Do not drop pipe or fittings
3. Do not roll or skid against pipe already on ground
4. Repair any damage done to coating or lining
5. Handle per manufacturer's recommendations
6. Store rubber gaskets in cool dark location
7. Store all material on wood pallets or timbers

C. Shop coated materials shall be handled, transported, stored and shipped in a manner that will prevent damage to the coating and lining. Coating or lining damaged in handling or other operations shall be repaired to the approval of and at no additional cost to the Owner

D. Any damage to the pipe or the protective coating from any cause during the installation of the pipeline and before final acceptance by the Engineer shall be repaired in accordance with these Specifications and at no additional cost to the Owner

E. Pipe
1. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation
2. PVC pipe has reduced flexibility and impact resistance as temperatures approach and drop below freezing. Extra care should be used in handling PVC pipe during cold weather
3. Do not store PVC pipe uncovered in direct UV light
4. Pipe stored along the trench side shall be suitably supported off the ground to avoid damage to the coating

F. Valves
1. Prepare valves for shipping as follows:
   a. Ensure that valves are dry and internally protected against rust and corrosion
   b. Protect valves against damage to threaded ends, flange faces, and weld ends
   c. Seal valve ends to prevent entry of foreign materials into valve body
   d. Set valves in best position for handling
   e. Set valves closed to prevent damage
2. Deliver and store valves and accessories in shipping containers with labeling in place
3. Storage: Use the following precautions for valves during storage:
   a. Do not remove end protectors unless necessary for inspection; then reinstall for storage
   b. Protect valves from weather by storing indoors or support valves off ground or pavement in watertight enclosures when outdoor storage is necessary

G. Precast Concrete Structures
1. Transport and handle precast concrete units with equipment to protect from dirt and damage
2. Do not place precast concrete units in position which will cause damage
3. Handle precast concrete structures by means of lifting inserts. Do not move from manufacturer's yard until curing is complete.

1.8 JOB CONDITIONS

A. All work which requires the interruption of active sanitary sewer service lines must be completed as quickly as possible in order to minimize inconvenience to customers and risk to the Town of Berthoud coordinated as specified in Division 1

B. Underground Obstructions
1. Underground Obstructions known to Engineer are shown on Drawings
   a. Locations shown may prove inaccurate and other obstructions not known to Engineer may be encountered
   b. Contractor shall field locate and verify all obstructions where or not shown on the Drawings
2. Notify each utility owner and request utility be field located by surface reference at least 48 hours prior to trenching or excavation
3. Expose and verify size, location and elevation of underground utilities and other obstructions where conflicts might exist sufficiently in advance to permit changes in the event of a conflict
   a. Notify Engineer and Owner in case of a conflict
   b. In case of a conflict, the proposed work may be changed by Engineer
4. Maintain, protect, and support by shoring, bracing or other means existing utilities and appurtenances
PART 2  PRODUCTS

2.1 PIPE, MANHOLES, AND ACCESSORIES

A. Comply with Town of Berthoud standards and specifications.

2.2 PVC GRAVITY SANITARY SEWER PIPE (NON-PRESSURE)

A. The following piping shall be non-pressure PVC pipe for gravity sanitary sewer application as indicated on the drawings and as specified herein
   1. Gravity sanitary sewer piping and fittings: 8-inch

B. Pipe and fittings: ASTM D3034, T-1 wall, SDR 35, non-pressure pipe
   2. Pipe length: 12-20 feet standard manufactured length for construction

C. Joints: ASTM D3212 and F477 - Rubber gasket with one compression gasket ring, integral bell and spigot type
   1. Designed to hold pipe in alignment, provide flexibility, separate the ends of pipe lengths, resist applied earth pressures, and provide fluid tightness
   2. Rubber rings: ASTM F477

2.3 PVC DRAIN OR VENT PIPE (NON-PRESSURE)

A. The following piping shall be non-pressure PVC pipe as indicated on the drawings and as specified herein
   1. Combination air release/vacuum breaker valve interior and exterior discharge vent piping and fittings: 1-inch and 4-inch diameter

B. Pipe and fittings: Schedule 40 in accordance with ASTM D1784, ASTM D1785, ASTM D2466, ASTM D2122, and ASTM F412

C. Joints:
   1. Solvent weld per manufacturer's recommendation
   2. Threaded: ANSI 82.1

2.4 SOURCE QUALITY CONTROL

A. Identification Marks: Clearly and permanently marked at not greater than 5 foot intervals with pipe diameter, PVC cell classification, manufacturer, plant, shift, ASTM, date designations and service designation

B. Testing per ASTM D3034
   1. Test products not manufactured in the U.S. at an acceptable laboratory in the U.S.

2.5 PIPE ACCESSORIES

A. Underground Type Plastic Line Marker
   1. Manufacturer's standard permanent, continuous-printed plastic tape with metallic core, intended for direct-burial service; not less than 6-inch wide x 4 mils thick. Provide green tape with black printing reading "CAUTION SANITARY SEWAGE LINE BURIED BELOW." Provide identification markers of one of the following:
      a. Allen Systems, Inc.
      b. Emed Co., Inc.
      c. Seton Name Plate Corp.
      d. Or accepted substitution

B. Tracer Wire for Buried Pipe
   1. Provide tracer wire for all HDPE pipe and PVC pipe
2. All tracer wire shall be 12 AWG solid copper wire coated with 45 mil Type HMW - PE blue insulation compliant with ASTM D1351 specifically designed for direct burial in corrosive soil or water
3. UL listed

C. Tracer Wire for Horizontal Directional Drilling
   1. Non-UL listed tracer wire specifically developed for Horizontal Directional Drilling application
   2. 1/4-inch 304 Stainless Steel tracer wire
      a. Performance Wire & Cable Inc.: "Tracer wire, Stranded SS/45 mil HMW-HDPE, 30 Volt, HDD direct bury use only"
   3. #12 AWG Solid Carbon Clad Steel Extra High Strength tracer wire
      a. Copperhead Industries, LLC: “Direct Burial #12 AWG Solid (.0808" diameter), 21% conductivity copper-clad hard drawn high carbon steel extra high strength horizontal directional drill tracer wire, 1150# average tensile break load, 45 mil. high molecular weight-high density polyethylene jacket complying with ASTM D1248, 30 volt rating”
      b. Pro-Line Safety Products Co.: “Pro-Trace HDD-CCS PE45”

D. Tracer Wire Test Stations
   1. 4-inch with locking lid
   2. Manufacturers:
      a. CP Test Services
      b. Glenn Series "Glenn-4"
      c. Or accepted substitution

E. Corrosion Control
   1. Rust inhibitive primer:
      a. Tnemec "Series 77H Chem-Prime"
      b. Or accepted substitution
   2. Rust preventative compound:
      a. Houghton "Rust Veto 344"
      b. Rust-Oleum "R-9"
      c. Or accepted substitution

2.6 AIR RELEASE AND VACUUM BREAKER COMBINATION VALVES

A. Manufacturers:
   1. Val-Matic “Model 801A”
   2. Dezurik/APCO “Series 440 SCAV”
   3. Or accepted substitution

B. Provide combination air release and vacuum breaker valves as indicated on Drawings
   1. Provide single body type that functions as both an air release and a vacuum breaker valve
   2. Valves shall be manufactured and tested in accordance with AWWA C512
   3. Provide a shutoff valve and transition piece from HDPE to NPT threaded connection on valve
      a. Ball valve: compatible with butt fusion, HDPE fitting

C. General
   1. Usage: Recommended for service up to 150 psi
   2. Bodies and covers:
      a. Gray iron meeting requirements of ASTM A126 Class B
      b. Globe style of 1-inch valves to increase float clearance and reduce clogging
   3. Exterior coating: universal alkyd primer
   4. Valve cleanout: 2" NPT
   5. Valve drain connection: 1" NPT
   6. Inlet and Outlet:
      a. Inlet: NPT, 2-inch on 1-inch valves
      b. Outlet: NPT equal to valve size, 1-inch
   7. Internals:
      a. Metal internal parts only
      b. Float sensitive skirt provided
c. Float, plug, guide shafts, and bushings: Type 316 stainless steel
d. Resilient seats: Buna-N

2.7 ECCENTRIC PLUG VALVES

A. Manufacturers:
   1. DeZurik
   2. Henry Pratt Company
   3. Milliken
   4. Val-Matic Valve and Manufacturing Corporation
   5. Or accepted substitution

B. Provide plug valves as indicated on Drawings

C. General
   1. Quarter-turn non-lubricated eccentric plug valves
   2. Resilient faced plug
   3. Valves with vane type seat rings are not acceptable
   4. Valve ends to match connecting piping
      a. Buried: Mechanical joint, ANSI A21.11/AWWA C111
      b. Flanged: 125 lb, ANSI B16.1
      c. Screwed valve ends shall be to the NPT standard
   5. Minimum Working Pressure Rating:
      a. 175 psi
   6. Opening motion eccentric, lifting plug away from body seat
   7. Valve alignment
      a. Valve shall be installed so that the plug is horizontal and rotates upward as the valve opens
      b. Valve shall be installed with seat on low pressure side of valve
   8. Provided with fully adjustable plug position stops
   9. Plugs shall be eccentric type with no backing ring or frame
   10. Valve body cavity shall be smooth without protrusions or baffles
   11. Valve body plainly marked to indicate seat end
   12. Valve packing adjustment accessible without removing actuator from valve

D. Valve Materials
   1. Plug and body: Cast iron, ASTM A126, Class B
   2. Resilient plug facing or replaceable style body seats shall be synthetic rubber, neoprene, or Buna N
      compound suitable for use with water and wastewater applications
   3. Seat rings shall be threaded, or welded of corrosion-resistant stainless steel (18-8), nickel, or Monel
      conforming to AWWA C504
   4. Sprayed or plated mating seat surfaces are not acceptable
   5. Bearings shall be replaceable. Sleeve type and thrust bearings in the upper and lower journals shall
      be corrosion-resistant stainless steel or bronze
   6. Shaft seals shall be multiple O-ring, self-adjusting U-cup or chevron type packing conforming to
      AWWA C504
   7. Pull-down packing is not acceptable
   8. Shaft seals shall be field adjustable or replaceable without valve disassembly
   9. Plug seat: Chloroprene (Neoprene)
   10. Packing: Acrylonitrile Butadiene V-Type Cup
      a. Dual U-cup
   11. Upper thrust bearing: TFE
   12. Body seat: Welded-in overlay seat of no less than 90% nickel
   13. Upper and lower trunnion bearings: Sleeve type, 18-8 stainless steel
   14. Valves complete with epoxy coating on the interior and exterior, manufacturer’s standard corrosion
      resistant coating shall be acceptable

E. Testing
   1. Valves shall be capable of drip-tight shut-off up to the full leak test rating
      a. Test and certify pressure capacity in the reverse direction
2.8 HATCH

A. Manufacturers:
   1. Bilco
   2. Or accepted substitution

B. Provide hatches as indicated on Drawings

C. Hatch shall be single leaf

D. Performance Characteristics
   1. Cover shall be reinforced to support a minimum live load of 300 psf with a maximum deflection of 1/150th of the span
   2. Operation of the cover shall be smooth and easy with controlled operation throughout the entire arc of opening and closing
   3. Operation of the cover shall not be affected by temperature
   4. Entire hatch, including all hardware components, shall be highly corrosion resistant

E. Cover
   1. Cover shall be 1/4" aluminum diamond pattern

F. Frame
   1. Channel frame shall be extruded aluminum with bend down anchor tabs around the perimeter

G. Hinges
   1. Shall be specifically designed for horizontal installation and shall be through bolted to the cover with tamperproof Type 316 stainless steel lock bolts and shall be through bolted to the frame with Type 316 stainless steel bolts and locknuts

H. Drain Coupling
   1. Provide a 1-1/2” drain coupling as indicated on Drawings

I. Lifting Mechanism
   1. Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the cover when closing
   2. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly
   3. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4” gusset support plate

J. A removable exterior turn/lift handle with a spring loaded ball detent shall be provided to open the cover and the latch release shall be protected by a flush, gasketed, removable screw plug

K. Hardware
   1. Hinges: Heavy forged Type 316 stainless steel hinges, each having a minimum 1/4" diameter Type 316 stainless steel pin, shall be provided and shall pivot so the cover does not protrude into the channel frame
   2. Cover shall be equipped with a hold open arm which automatically locks the cover in the open position
   3. Cover shall be fitted with the required number and size of compression spring operators. Springs and spring tubes shall be Type 316 stainless steel
   4. A Type 316 stainless steel snap lock with a fixed handle shall be mounted on the underside of the cover
   5. Hardware: Shall be Type 316 stainless steel throughout
   6. Ladder Up post

L. Finishes
   1. Factory finish shall be mill finish aluminum with bituminous coating applied to the exterior of the frame
2.9 MANHOLES

A. Precast Concrete Units:
   1. Manufacturers:
      a. Rinker Materials
      b. Old Castle Precast
      c. Or accepted substitution
   2. Specification: ASTM C478
   3. Minimum wall thickness: greater of 5 inch or 1/12 of internal diameter
   4. Reinforced
   5. Grade rings as required

B. Precast Units or Cast-in-place as shown. Use concrete that will attain a 28-day compressive strength of not less than 4500 psi with a cement content of not less than 6 sacks per cu. yd. Openings to be precast per plan. Sawcut in field only if no other option.

C. Cast-in-place Concrete Units: As shown on the drawings complying with the Town of Berthoud and Colorado Department of Transportation drainage and design standards

D. Manhole Steps: Steel bar, 1/2 inch Grade 60, drop-front type, with polypropylene coating applied by manufacturer, Type MA Industries, Inc. "PS2-PF" or equal [OR] Manhole Steps: Aluminum, drop-front type with polypropylene coating applied by manufacturer, Type MA Industries Inc. "PS2-PF" or approved substitution

2.10 FABRICATION

A. Vault/Manhole Sections
   1. Precast concrete dimensions as shown on plans
   2. Minimum manhole inside diameter: 48 inch
   3. Precast lid and Cones: Same or greater reinforcement and wall thickness as vault or manhole section with capability for H20 loading
   4. Vault Joints: Shiplap or tongue and groove with double mastic gaskets, each joint to set equally and tightly
   5. Manhole Joints: Keylock type with double mastic gaskets, each joint to set equally and tightly
   6. Access opening: Minimum 24 clear or as indicated
   7. Pipe connection: As indicated on Drawings
   8. Pipe knockout: As indicated on Drawings
   9. Precast concrete, monolithic base or cast-in-place base
   10. Manhole steps: 12 inch on center, vertical alignment above largest bench or open area

B. Grating and Metal Frame: As specified on drawings

2.11 ACCESSORIES

A. Plugs and Caps: Use pipe plugs or caps provided by the pipe manufacturer and approved by the Engineer for pipe stubouts

B. Cleanouts: Provide as indicated, pipe extension to grade with ferrule and countersink cleanout plug. Provide round cast-iron access frame over cleanout, with heavy duty secured scoriated cover with lifting device cast with the word "SANITARY"

C. Reinforcement:
   1. Reinforcing Steel: ASTM A615 Grade 60
   2. Welded Wire Fabric: ASTM A185

D. Concrete: Refer to Division 3 Specifications if applicable
   1. Minimum compressive strength: ASTM C39, 4500 psi at 28 days
   2. Cement: ASTM C150, Portland Cement, Type II
3. Aggregates: ASTM C33, free of deleterious substances

E. Gaskets: ASTM C923
   1. Mastic: FS SS-S-210A, "RAM-NEK" or approved substitution
   2. Rubber: Neoprene, 40±5 hardness when measured by ASTM D2240, Type A durometer

F. Boots: ASTM C923
   1. Flexible rubber boots

G. Frames and Castings: ASTM A48 with asphalt varnish coating hot dip applied at foundry, 6 mils thick Class 30b

H. Manhole Rings and Covers
   1. Cast iron, heavy duty traffic type, ASTM A48, Class 35B. Grind bearing surfaces to ensure flat, true surfaces
   2. Covers to seat at all points on ring
   3. Covers to be cast with “SANITARY” in 2” tall flush letters
   4. Provide type as indicated on the drawings

I. Manhole Height Adjustment: Use precast concrete grade rings

J. Rock Subbase: 1-1/2 inch minus, well-graded gravel over compacted subgrade

K. Water: Clean and free of deleterious substances

L. Grout: Provide under provisions of Division 3 Specifications

2.12 GROUT MANUFACTURERS

A. Non-Shrink, Non-Metallic Grout
   1. Master Builders: Masterflow 928
   2. Burke: Non-Ferrous Non-Shrink
   3. M.R. Meadows: Sealtight 588
   4. Sonneborn: Sonogrout G.P.
   5. Tamms: Tammsgrout 621
   6. Sika: SikaGrout 212
   7. Or accepted substitution

B. Epoxy Grout
   1. Burke: BurkEpoxy Anchoring Grout
   2. L&M Inc.: Epogrout
   3. Sika: Sikadur 42, Grout Pack
   4. Or accepted substitution

2.13 CONCRETE MATERIALS

A. Follow requirements specified in Division 3 Specifications

2.14 SOIL MATERIALS

A. Furnish pipe bedding and cover as specified in Section 31 00 00
PART 3 EXECUTION

3.1 INSPECTION

A. Examine pipe and fittings and do not use individual sections containing cracks, dents, abrasions, and other defects

3.2 INSTALLATION OF HDPE PRESSURE PIPE

A. Trenching, Pipe Embedment, Backfill, and Compaction: See Section 31 00 00

B. Pipe and Fittings
   1. Follow pipe manufacturers installation instructions for field cutting and fusion joining techniques for HDPE pipe
      a. Include acceptable size and shape of fusion bead; and minimum radius of curvature of various sizes of pipe for installing curved sections of pipe
   2. Carefully lower pipe, fittings, valves, and accessories into the trench with derricks, ropes, and other suitable equipment to prevent damage
   3. Do not dump or drop pipe or accessories into trench
   4. Lay to lines and grades indicated on drawings or as specified
      a. Lay piping beginning at a low point of system, true to line and grade with unbroken continuity of invert.
      b. Join to form a smooth flow line
   5. Do not install flanges, fittings, or valves in curved sections of pipe
   6. Keep pipe clean during and after laying
   7. Close all open ends with watertight expandable type sewer plugs or test plugs
   8. Do not lay pipe when
      a. There is water in the trench
      b. Trench conditions are unsuitable
      c. Weather conditions are unsuitable
   9. Use acceptable adaptors at manhole and structure connections to provide a watertight seal and flexibility; provide a short length of pipe outside each connection
   10. Protect from lateral displacement by placing and compacting bedding material under provisions of Section 31 00 00
   11. Protect pipe from hot and cold thermal expansion using manufacturer and other recommended techniques

C. Joining
   1. Use butt fusion joining technique for connections between pipe sections or fittings unless otherwise noted herein.
   2. Butt Fusion
      a. Sections of polyethylene pipe should be joined into continuous lengths on the jobsite above ground.
      b. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations.
      c. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer.
      d. The butt fusion joining will produce a joint weld strength equal to or greater than the tensile strength of the pipe itself.
   3. Sidewall Fusion
      a. Sidewall fusions for connections to outlet piping shall be performed in accordance with HDPE pipe and fitting manufacturer's specifications.
      b. The heating iron used for sidewall fusion shall have an inside diameter equal to the outside diameter of the HDPE pipe being fused.
      c. The size of the heating iron shall be ¼ inch larger than the size of the outlet branch being fused.
   4. Mechanical
      a. Bolted joining may be used where the butt fusion method cannot be used.
      b. Flange joining will be accomplished by using a HDPE flange adapter with a ductile iron back-up ring.
c. Mechanical joint joining will be accomplished using either a molded mechanical joint adapter or the combination of a Sur-Grip Restrainer and Pipe Stiffener as manufactured by JCM Industries, Inc.
d. Either mechanical joint joining method will have a ductile iron mechanical joint gland.

5. Other
a. Socket fusion, hot gas fusion, threading, solvents, and epoxies may not be used to join HDPE pipe.

D. Water Line and Sanitary Sewer Crossings
1. Whenever possible lay water mains over sanitary sewers to provide vertical separation of at least 18-inches between invert of water main and crown of sewer.
2. If above separation cannot be met, provide one continuous length of watertight sewer pipe 20 feet long centered on water main with joints between different pipes encased in 6-inch minimum of concrete and extending 6-inches either side of joint or encase sewer pipe in 6-inches of concrete completely around pipe, for not less than 10 feet either side of water main.
3. Water Mains Passing Under Sewers: If vertical separation less than 18-inches provide structural support for sewer.

3.3 INSTALLATION OF PVC GRAVITY SANITARY SEWER PIPE (NON-PRESSURE)

A. Trenching, Pipe Embedment, Backfill, and Compaction: See Section 31 00 00

B. Install pipe in accordance with ASTM D2321 as modified herein or on the drawings

C. Cutting
1. Cut and bevel ends in accordance with manufacturer's standard recommendations
2. Machine cut ends smooth and square to proper dimensions
3. Do not cut with a cold chisel, iron pipe cutter, flame or any other method that may fracture the pipe or leave ragged, uneven edges
4. Remove burrs and wipe off all dust and dirt from jointing surfaces

D. Pipe Laying
1. Inspect pipe and accessories for cracks and other defects before lowering into trench
2. Repair or replace any defective, damaged or unsound pipe
3. Remove all dirt and foreign material from the inside of pipe before laying
4. Check bedding for firmness and uniformity of surface immediately before laying each section of pipe
5. Carefully lower pipe, fittings, valves, and accessories into the trench with derricks, ropes, and other suitable equipment to prevent damage
6. Do not dump or drop pipe or accessories into trench
7. Lay to lines and grades indicated on drawings or as specified
   a. Lay piping beginning at a low point of system, true to line and grade with unbroken continuity of invert.
   b. Closely joint to form a smooth flow line
   c. Place bell end or groove ends of piping facing upstream
   d. Maximum length of pipe that can be used without exceeding the allowable deflection at a coupling shall be determined
   e. Maximum deflection at flexible couplings as recommended by the manufacturer
   f. Maximum deflection at a joint: As recommended by the manufacturer, but not more than 3-1/2 inches
8. Utilize implements, tools, and facilities as recommended by the manufacturer
9. Keep pipe clean during and after laying
10. Close all open ends with watertight expandable type sewer plugs or test plugs
11. Remove and relay any pipe which has floated
12. Do not lay pipe when
   a. There is water in the trench
   b. Trench conditions are unsuitable
   c. Weather conditions are unsuitable
13. Use acceptable adaptors at manhole and structure connections to provide a watertight seal and flexibility; provide a short length of pipe outside each connection
14. Protect from lateral displacement by placing and compacting bedding material under provisions of Section 31 00 00
E. Jointing
1. Assemble in accordance with the manufacturer's instructions
2. Wipe clean pipe ends, gasket and gasket groove before inserting gasket
3. Apply lubricant furnished by the pipe manufacturer to the gasket and the outside of the spigot end
4. Utilize an assembly tool as recommended by the manufacturer to center the sleeve over the spigot end
5. Insert the spigot end to the reference mark
6. Check gasket location after assembly with a suitable gage
   a. Gasket locations to be the distance from the sleeve and recommended by the coupling manufacturer for their full circumference
   b. If not within the required limits, disassemble and reassemble the joint

F. Fittings
1. Install utilizing standard methods
2. Lower into trench with rope or other means to prevent damage
3. Attach rope around the exterior
4. Do not attach rope through the interior
5. Carefully connect to pipe or other facility
6. Check joint to insure a sound and proper joint

G. Water Line and Sanitary Sewer Crossings
1. Whenever possible lay water mains over sanitary sewers to provide vertical separation of at least 18-inches between invert of water main and crown of sewer.
2. If above separation cannot be met, provide one continuous length of watertight sewer pipe 20 feet long centered on water main with joints between different pipes encased in 6-inch minimum of concrete and extending 6-inches either side of joint or encase sewer pipe in 6-inches of concrete completely around pipe, for not less than 10 feet either side of water main.
3. Water Mains Passing Under Sewers: If vertical separation less than 18-inches provide structural support for sewer

3.4 INSTALLATION OF HATCH
A. The installer shall comply with the hatch Manufacturer's installation instructions

3.5 MANHOLE PREPARATION
A. Verify items provided by other section of Work are properly sized and located
B. Verify that built-in items are in proper location, ready for roughing into Work
C. Verify excavation for manholes is correct
D. Excavation, Backfill, Subgrade Compaction: Refer to Section 31 00 00 for requirements

E. Rock Subbase
1. Remove water and place 6-inch minimum depth
2. Vibrate for compaction
3. Level top to accept precast sections with uniform bearing all around
4. If material below vault is unsuitable, excavate as directed by the Engineer and backfill to grade with 1-1/2 inch minus rock and compact

3.6 PLACING MANHOLE
A. Place base pad, trowel top surface level to accept manhole section with uniform bearing all around
B. Place sufficient non-shrink grout on base to ensure watertight fit between first manhole section and base of place first manhole section directly in wet concrete
C. Place manhole sections plumb and level, trim to correct elevations
D. Clean ends of sections and place double mastic gasket
E. Fill inside and outside of joint completely with non-shrink grout and trowel smooth
F. Cure non-shrink grout using approved methods outlined in Division 3 Specifications.
G. Set cover rings and covers level without tipping, to correct elevations or set cover rings and covers with slight tip to match cross slope of finished surface where directed by Engineer
H. Completed manholes shall be rigid and watertight
I. Coordinate with other sections of work to provide correct size, shape, and location

3.7 PREFORMED GASKETS
A. Remove and replace manhole sections which have chipped or cracked joints
B. Thoroughly clean section joints
C. Install gasket in conformance with manufacturer's recommendations
D. Only use primer furnished by gasket manufacturer

3.8 MANHOLE INVERT
A. Place concrete in bottom of manhole and form smooth transition. Trowel smooth and brush for non-skid finish. Slope bench 1 inch per foot for drainage to invert.
B. Invert shape to conform to radius of pipe it connects
C. Remove all rough sections or sharp edges which tend to obstruct flow or cause material to snag. Remove all grout droplets from invert
D. Construct in conformance with standard drawings

3.9 MANHOLE RINGS AND COVERS
A. Place rings in bed of non-shrink grout on top of manholes. Ensure no infiltration will enter manhole at this location.
B. Carry non-shrink grout over flange of ring
C. Set top of ring flush with all surfaces subject to foot and vehicular traffic or as required by Town of Berthoud
D. Set manhole ring and cover 1/4-inch to 1/2-inch below roadway surface
E. Use precast grade rings for height adjustment of manhole ring and cover

3.10 CONNECTION TO EXISTING MANHOLES
A. Maintain flow at all times
B. Prior approval of proposed method for maintaining flow must be obtained from Engineer
C. Cover area around new pipe with non-shrink grout and or waterstop gasket to ensure a watertight structure
D. Make connection during low flow periods
A. General
1. Utilize pressures, media and pressure test durations as specified on Piping Schedules
2. Isolate equipment which may be damaged by the specified pressure test conditions
3. Perform pressure test using calibrated pressure gauges and calibrated volumetric measuring equipment to determine leakage rates. Select each gauge so that the specified test pressure falls within the upper half of the gauge's range. Notify Engineer 24 hours prior to each test
4. Completely assemble and test new piping systems prior to connection to existing pipe systems
5. Acknowledge satisfactory performance of tests and inspections in writing to Engineer prior to final acceptance
6. Provide all necessary equipment and perform all work required in connection with the tests and inspections
7. Bear the cost of all testing and inspecting, locating and remedying of leaks and any necessary retesting and re-examination

B. Testing methods and criteria
1. Ductile iron pipe systems: Test ductile iron pipe in accordance with the latest version of AWWA C600. Per AWWA C600, the allowable leakage in gallons per hour from buried ductile iron pipe systems shall be less than the length of pipeline tested in feet, times the nominal diameter of the pipe in inches, times the square root of the average test pressure during the leakage test in pounds per square inch (gauge), divided by 133,200. The duration of each leakage test shall be two hours. The equation for computing the allowable leakage is:

   \[ L = \frac{(SDP^{0.5})}{133,200} \]

   Where:
   
   \( L \) = allowable leakage, in gallons per hour
   
   \( S \) = length of the pipe tested, in feet
   
   \( D \) = nominal diameter of the pipe, in inches
   
   \( P \) = average test pressure during the leakage test, in psi

2. Polyethylene (PE) pressure pipe systems: Test PE pressure pipe in accordance with the latest version of ASTM F2164. For PE pipe, pressurize the test section to the system test pressure and maintain this pressure for four hours by adding make-up water. After this initial expansion phase, reduce the test pressure by 10 PSI and stop adding make-up water. If the test pressure remains steady (within 5% of the target value) for one hour, no leakage is indicated.

3. Unless otherwise specified, the allowable leakage in gallons per hour from other buried liquid piping systems shall be less than the length of pipeline tested in feet, times the nominal diameter of the pipe in inches, times the square root of the average test pressure during the leakage test in pounds per square inch (gauge), divided by 133,200. The duration of each leakage test shall be two hours. The equation for computing the allowable leakage is:

   \[ L = \frac{(SDP^{0.5})}{133,200} \]

   Where:
   
   \( L \) = allowable leakage, in gallons per hour
   
   \( S \) = length of the pipe tested, in feet
   
   \( D \) = nominal diameter of the pipe, in inches
   
   \( P \) = average test pressure during the leakage test, in psi

4. The following liquid piping systems shall have zero allowable leakage at the specified test pressure throughout the specified duration:
   a. Exposed piping
   b. Buried insulated piping
   c. Buried or exposed piping carrying liquid chemicals

5. Hydrostatic pressure testing
   a. For buried piping: Perform testing after backfill and proper compaction of trenches. Where lines are installed under roadways and parking areas, perform tests after completion of final grade preparation and prior to application of surface courses. Notify Engineer at least 48 hours prior to testing. Provide
temporary restraints for expansion joints for additional pressure load under test. Isolate equipment in piping system with rated pressure lower than pipe test pressure by valves or blind flanges.

6. Low pressure air test
   a. Check pneumatic plugs for proper sealing
   b. Place plugs in line at each manhole and inflate to 25 PSIG
   c. Introduce low pressure air into sealed line segment until air pressure reaches 4 PSIG greater than ground water that may be over the pipe. Use test gauge conforming to ANSI B40.1 with 0 to 15 PSI scale and accuracy of 1 percent of full range
   d. Allow 2 minutes for air pressure to stabilize
   e. After stabilization period (3.5 PSIG minimum pressure in pipe) discontinue air supply to line segment
   f. Acceptable time for loss of 0.5 PSIG of air pressure in plastic pipe shall be:

<table>
<thead>
<tr>
<th>Pipe</th>
<th>≤100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
<th>400</th>
<th>450</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Inch</td>
<td>7:05</td>
<td>7:05</td>
<td>8:54</td>
<td>11:08</td>
<td>13:21</td>
<td>15:35</td>
<td>17:48</td>
<td>20:02</td>
<td>22:16</td>
</tr>
</tbody>
</table>

NOTE: If there has been no (zero psi) drop after 1 hour of testing, the test section shall be accepted and the test completed.

h. For pipe lengths not shown in the above table, use the two nearest pipe lengths to estimate the minimum time necessary for a 0.5 PSIG loss
i. For concrete pipe 24" and smaller refer to ASTM C-924 for acceptable test procedures and times
j. For concrete pipe 24" and larger refer to ASTM C-1103 for acceptable test procedures and times

7. Hydrostatic Exfiltration/Infiltration Test
   a. Hydrostatic Exfiltration Test (groundwater level is below the top of pipe)
      i) Allowable Leakage rate: 50 gallons per IN diameter per mile of pipe per day
   b. Hydrostatic Infiltration Test (groundwater level is above the top of pipe)
      i) Allowable leakage rate: 50 gallons per IN diameter per mile of pipe per day

8. Notify Engineer of the date and time for each pipe test 1 week prior to actual testing

C. Exfiltration/Infiltration Test
   1. Perform an exfiltration test on each reach of sanitary service and sewer pipe between manholes or discharge
      a. Test the first reach prior to backfilling and before installing any of the remaining pipe
      b. Provide all necessary piping between the reach to be tested and the water supply, together with all required materials and equipment
      c. Methods used, scheduling, and duration of tests shall be acceptable to Engineer
      d. Air testing may be allowed: Submit complete information to Engineer for review describing the proposed test method including the method of testing manholes before beginning testing

2. Procedure
   a. Block off all manhole openings except those connecting with the reach under test
   b. Fill the line
      i) Average depth: 10 feet above invert except as required by manhole depth
      ii) Maximum depth at lower end: 25 feet above crown
      iii) Minimum depth at upper end: 5 feet above crown
   c. Add and measure water as required to maintain a constant level
i) Maximum exfiltration/infiltration: 0.039 gallons per inch of nominal diameter per hour per 100 feet of pipe.
ii) Manholes considered section of 48-inch pipe
iii) Maintain test for at least 2 hours or as long as necessary, in the inspector’s opinion, to locate all leaks
3. Repair and retest any reach which exceeds the allowable exfiltration/infiltration

D. Infiltration
1. At any time prior to expiration of the correction period, infiltration exceeds 0.039 gallons per inch of nominal diameter per 100 feet per hour, locate the leaks and make repairs

E. Dielectric Testing Methods and Criteria
1. Provide electrical check between metallic non-ferrous pipe or appurtenances and ferrous elements of construction to assure discontinuity has been maintained
2. Wherever electrical contact is demonstrated by such test, locate the point or points of continuity and correct the condition
3. Check the integrity of each cadwelding connection using a light hammer blow at a 45-degree angle

F. Pipe Deflection Test
1. No sooner than 30 days after placement and compaction of backfill, but prior to placement of permanent surface materials, clean and mandrel each line to detect obstructions (deflections, joint offsets, lateral pipe intrusions, etc.)
2. Use a rigid mandrel with diameter of at least 95 percent of the pipes specified average inside diameter and a length of the mandrel circular portion at least equal to the nominal pipe diameter
3. Maximum allowable deflection is 5 percent of the base internal diameter. Mandrel outside diameters in inches are as follows:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Base I.D.</th>
<th>Mandrel O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5.792</td>
<td>5.50</td>
</tr>
<tr>
<td>8</td>
<td>7.764</td>
<td>7.38</td>
</tr>
<tr>
<td>10</td>
<td>9.711</td>
<td>9.23</td>
</tr>
<tr>
<td>12</td>
<td>11.558</td>
<td>10.98</td>
</tr>
</tbody>
</table>
4. Pull the mandrel through the pipe by hand
5. Relay or replace all pipe exceeding the 5 percent deflection at no additional cost to the Owner
6. Retest repaired sections
7. Maximum allowable deflection at end of one year correction period, 7-1/2 percent of the base internal diameter tested in the same manner. Uncover and repair sections exceeding the allowable deflection

G. TV Inspection will be provided as requested by Owner and approved by the Engineer at the expense of the Contractor. Digital video files to be provided with reach noted, footage, inverts, and manhole number at each end, and pipe size and type

H. All sewer lines shall be inspected visually to verify accuracy of alignment and freedom from debris and obstructions. The full diameter of the pipe should be visible when viewed between consecutive manholes. The method of test can be photography, closed circuit television or visually lamping with mirrors and lights.

I. Lamp Test
1. Each section between manholes will be lamped by Contractor in the presence of engineer
2. A true circle will be required in the lamp tests to indicate a properly constructed sewer line
3. Repair any sections not passing the lamp test at Contractor’s expense.

3.12 FIELD QUALITY CONTROL – MANHOLES

A. Test all manholes:
1. Vacuum test:
   a. Plug all inlets and outlets in such a manner as to prevent displacement of plugs
b. Install and operate vacuum tester head assembly in accordance with equipment specifications and manufacturer instructions

c. Attach the vacuum pump assembly to the proper connection on the test head assembly. Ensure that vacuum inlet/outlet valve is closed

d. Inflate sealing element to twice the pressure test to be used. Do not over inflate

e. Start vacuum pump assembly engine and allow preset RPM to stabilize

f. Open vacuum inlet/outlet valve and evacuate manhole to 5-inches Hg (mercury)

g. Close vacuum inlet/outlet valve, disconnect vacuum pump and monitor vacuum. Record time for vacuum to drop from initial 5 inches Hg to 4 inches Hg.

h. Acceptance for 5 foot diameter manhole is when the time to drop from 5 inches Hg to 4 inches Hg meets or exceeds requirements as defined below:

<table>
<thead>
<tr>
<th>Manhole Depth Rim to Invert</th>
<th>Manhole Diameter in feet</th>
<th>Time for Vacuum to Drop 1 inch Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 feet or less</td>
<td>5</td>
<td>150 seconds</td>
</tr>
<tr>
<td>10 feet to 15 feet</td>
<td>5</td>
<td>180 seconds</td>
</tr>
<tr>
<td>15 feet to 25 feet</td>
<td>5</td>
<td>210 seconds</td>
</tr>
</tbody>
</table>

i. Adjust time to drop from 5 inches Hg to 4 inches Hg for other manhole diameters as follows:
   i) 4 foot diameter manhole: Subtract 30 seconds from time shown above
   ii) 6 foot diameter manhole: Add 30 seconds to time shown above

j. Repair all manholes that fail leakage test and retest until manhole passes test at no additional cost

k. If joint mastic or gasket is displaced during vacuum test, disassemble manhole and replace seal

l. If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn. Retesting shall proceed until a satisfactory test is obtained.

2. All testing shall be witnessed by Engineer. Contractor shall provide a minimum of 48 hours notice to Engineer prior to testing.

3.13 CLEANUP AND RESTORATION

A. Restore pavements, curbs and gutters, utilities, and other improvements to condition equal to or better than before work began and to satisfaction of Engineer.

B. Deposit waste material in designated waste areas and disposal site graded and shaped.

3.14 FINAL ACCEPTANCE

A. Comply with Town of Berthoud standards and specifications for placing sewer line in service

B. The inside of all pipe, valves, and fittings shall be smooth, clean, and free from blisters, loose mill scale, sand, and dirt when connected.
   1. Wire brush, if necessary, wipe clean and keep joint contact surfaces clean until connection is complete

C. Provide record drawings with manhole number, inverts, and location (x, y, z) for each service connection

D. Provide test report for tracer wire continuity

E. Provide pipe and manhole tests and results

F. Provide video files of TV inspection on a DVD

END OF SECTION
SECTION 33 4000
STORM DRAINAGE SYSTEMS

PART 1   GENERAL

1.1  SECTION INCLUDES
A. Piping and concrete structures for storm sewer system, roof drainage, and culverts
B. Riprap for channel lining, outlet protection and rock check dams

1.2  REFERENCES
A. ACPA - American Concrete Pipe Association
B. ASTM C76 - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
C. ASTM C150 - Portland Cement
D. ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
E. ASTM C478 – Precast Concrete Structures
F. ASTM C497 - Testing Concrete Pipe, Manhole Sections, or Tile
G. ASTM A48 - Gray Iron Castings
H. ASTM A185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
I. ASTM A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
J. ASTM C33 - Concrete Aggregates
K. ASTM C478 - Precast Reinforced Concrete Manhole Sections
L. ASTM 990 -
M. Urban Storm Drainage Criteria Manual, Urban Drainage and Flood Control District (UDFCD)
N. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction

1.3  DESIGN REQUIREMENTS
A. Comply with applicable requirements of ASTM C76
B. Comply with Town of Berthoud, Urban Storm Drainage Criteria Manual, Urban Drainage and Flood Control District (UDFCD), and CDPHE Stormwater and/or Groundwater Discharge Permit and related storm design criteria. If standards conflict, the more stringent criteria shall govern.

1.4  SUBMITTALS
A. Submit under provisions of Division One Specifications
B. Shop Drawings: Provide drawings with pipe and structure details, design standards, reinforcement, dimensions, etc. Provide additional detailed information (including elevations, fittings, specialty materials or fabrications, etc.) for special or custom features, structures, junctions and/or pipes. Provide pipe-laying schedule.

C. Product Data: Provide sufficient data on features, pipe, joints, gasket material, lubricant and accessories to verify compliance with specifications.

D. Manufacturers Certificate: Certify that pipe, meets or exceeds specified requirements. Confirm all materials comply with applicable standards.

E. Test Reports: Submit all shop and field test reports in accordance with Division One Specifications

F. Provide sufficient data to verify compliance with these specifications.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery
   1. Ship rubber gaskets in cartons and store in a clean area away from grease, oil, ozone producing electric motors, heat and the direct rays of the sun

B. Storage
   1. Store pipe, fittings and gaskets in clean locations protected from environmental conditions such as: (direct sunlight, mud, etc.)
   2. Do not use pipe and fittings stored in direct sunlight for periods in excess of 18 months
   3. Store pipe on a flat surface which provides even support for the barrel with bell ends overhanging
      a. Do not stack pipe higher than 5 feet

C. Handling
   1. Handle so as to insure installation in sound undamaged condition.
   2. Use equipment, tools and methods for unloading, reloading, hauling and laying that do not damage pipe or cause an impact. Damaged pipe will be cause for rejection
   3. Use hooks or straps with broad, well-padded contact surfaces for lifting sections of pipe

1.6 ENVIRONMENTAL REQUIREMENTS

A. Weather limitations: Do not install piping over frozen surfaces or in standing water.

PART 2 GENERAL PRODUCTS

2.1 PIPE MATERIALS

A. Comply with Town of Berthoud standards and specifications for public storm sewer products.

B. General: Provide pipes of one of the following materials, of weight/class indicated. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated

C. Fittings: Furnish bends, ells, tees, wyes, couplings and other fittings of the same type and class of material having equal or superior physical and chemical properties as acceptable to the Engineer

D. Reinforced Concrete Pipe: ASTM C76,
1. 12-inch RCP Class V, with modified tongue-and-groove compression gasket joints complying with ASTM C443.
2. 15-inch RCP Class IV (Class V when specified on plans), with modified tongue-and-groove compression gasket joints complying with ASTM C443.
3. 18-inch thru 24-inch RCP Class III (Class IV or V when specified on plans), with modified tongue-and-groove compression gasket joints complying with ASTM C443.
4. 24-inch thru 36-inch RCP Class II (Class III, IV or V when specified on plans), with modified tongue-and-groove compression gasket joints complying with ASTM C443.

E. PVC Sewer Pipe: ASTM D3034, Type PSM, SDR 35 with PVC, elastomeric joints complying with ASTM D3212 using elastomeric seals complying with ASTM F477.

F. HDPE Sewer Pipe: smooth interior, corrugated exterior piping conforming to ASTM D 2412, ASTM D 3212, AASHTO specifications M252 and M 294, joints to conform to ASTM F 477.

2.2 MATERIALS

A. Comply with Town of Berthoud standards and specifications for public storm sewer products.

B. Plugs and Caps: Use pipe plugs or caps provided by the pipe manufacturer and approved by the Engineer for pipe stubouts.

C. Cleanouts: Provide as indicated, pipe extension to grade with ferrule and countersink cleanout plug. Provide round cast-iron access frame over cleanout, with heavy duty secured scoriated cover with lifting device cast with the word “STORM”.

D. Reinforcement
   1. Reinforcing Steel: ASTM A615 Grade 60
   2. Welded Wire Fabric: ASTM A185

E. Concrete:
   1. Minimum compressive strength: ASTM C39, 4500 psi at 28 days
   2. Cement: ASTM C150, Portland Cement, Type II
   3. Aggregates: ASTM C33, free of deleterious substances

F. Gaskets:
   1. ASTM C923 for resilient connectors
   2. ASTM C990 for preformed flexible joint sealants
   3. FS SS-S-210A, "RAM-NEK" or accepted substitution
   4. Rubber: 40± 5 hardness when measured by ASTM D2240, Type A durometer

G. Inlet Gratings and Manhole Rings and Covers
   1. Cast iron, heavy duty traffic type, ASTM A48, Class 35B. Grind bearing surfaces to ensure flat, true surfaces
   2. Provide bike/pedestrian-safe grates where such traffic is anticipated
   3. Set grate on frame such that openings maximize inlet intake
   4. Covers to seat at all points on ring
   5. Covers to be cast with “STORM” in 2” tall flush letters
   6. Manhole covers to receive asphalt varnish coating hot dip applied at foundry, 6 mils thick

H. Manhole Height Adjustment: Use precast concrete grade rings

I. Rock Subbase: 1-1/2 inch minus, well-graded gravel over compacted subgrade

J. Water: Clean and free of deleterious substances
K. Grout:
1. Non-Shrink, Non-Metallic Grout: Factory premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents, capable of developing minimum compressive strength of 4000 psi in one day and 8000 psi in 7 days
2. Epoxy Grout: Three Component Epoxy Resin System
   i) Two liquid epoxy components
   ii) One inert aggregate filtered component
   iii) Each component furnished in separate package for mixing at job site

2.3 CONCRETE CATCH BASINS AND MANHOLES

A. Comply with Town of Berthoud standards and specifications for public storm sewer products.

B. Precast Concrete Units:
   1. Manufacturers: Carder Concrete Products, Amcor Precast, or accepted equal
   2. Specification: ASTM C478 and C789, wall "B"
   3. Minimum wall thickness: greater of 6 inch 1/12 of internal diameter
   4. Reinforced
   5. Grade rings as required
   6. Cast steps into units.

C. Precast Units or Cast-in-place as shown. Use concrete that will attain a 28-day compressive strength of not less than 4500 psi with a cement content of not less than 6 sacks per cu. yd. Openings to be precast per plan or sawcut in field.

D. Cast-in-place Concrete Units: As shown on the drawings complying with the Town of Berthoud and Colorado Department of Transportation drainage and design standards.

E. Manhole Steps: Steel bar, 1/2 inch Grade 60, drop-front type, with polypropylene coating applied by manufacturer, Type MA Industries, Inc. "PS2-PF" or equal

2.4 PVC PLASTIC INLINE DRAINS AND DRAIN BASINS

A. Manufacturer: Nyloplast America Inc. or accepted substitution.

B. Inline drains and drain basins shall be manufactured from PVC pipe stock, utilizing a thermomolding process to reform the pipe stock to the furnished configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. The joint tightness shall conform to ASTM D3212.

C. Surface drainage products shall meet the mechanical property requirements for fabricated fittings as described in ASTM F794, F949 and F1336.

D. Inline drain and drain basin adapters and accessories
   1. Adaptable to SDR-35 PVC piping.
   2. Watertight adaptors.

E. Cast iron or ductile iron frames and grates:
   1. Light –traffic rated
   2. Pedestrian rated
   3. Hinged and locking
   4. Made specifically for use with the specified inline drains and drain basins
   5. Painted black
   6. ASTM A-48-83 Class 30B or A536 grade 70-50-05 grade iron
   7. Size indicated on the drawings
2.5 CONCRETE FABRICATION

A. Comply with Town of Berthoud standards and specifications for public storm sewer products.

B. Vault/Manhole Sections
   1. Precast concrete dimensions as shown on plans
   2. Minimum manhole inside diameter: 48 inch
   3. Precast lid and Cones: Same or greater reinforcement and wall thickness as vault or manhole section with capability for H20 loading
   4. Vault Joints: Shiplap or tongue and groove with double mastic gaskets, each joint to set equally and tightly
   5. Manhole Joints: Keylock type with double mastic gaskets, each joint to set equally and tightly
   6. Access opening: Minimum 24 clear or as indicated
   7. Pipe connection: As indicated on Drawings
   8. Pipe knockout: As indicated on Drawings
   9. Precast concrete, monolithic base or cast-in-place base
   10. Manhole steps: 12 inch on center, vertical alignment above largest bench or open area

C. Grating and Metal Frame: As specified on drawings

2.6 SOIL MATERIALS

A. Comply with Town of Berthoud standards and specifications for public storm sewer products.

B. Furnish pipe bedding and cover as specified in Section 3100 00 – Earthwork.

C. Riprap Materials:
   1. Hard, dense, durable stone, angular in shape and resistant to weathering
   2. Minimum specific gravity of 2.5
   3. Material may be approved by Engineer, if by visual inspection, the rock is determined to be sound and durable
   4. Engineer may require Contractor to furnish laboratory test results if the material appears to be marginal or unacceptable
   5. Tested material shall meet the following requirements for abrasion resistance or compressive strength:

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion Resistance by Los Angeles Machine</td>
<td>ASTM C 535</td>
<td>50% loss, max</td>
</tr>
<tr>
<td>Unconfined Compressive Strength of Drilled Core Specimen</td>
<td>AASHTO T 24</td>
<td>2500, min</td>
</tr>
</tbody>
</table>

6. Contractor shall provide a five ton sample of riprap indicating the compliance to required material soundness and gradation specifications if requested by the Engineer.

7. Gradation:

<table>
<thead>
<tr>
<th>Riprap Designation</th>
<th>% Smaller Than Given Size By Weight</th>
<th>Intermediate Rock Dimension (Inches)</th>
<th>Mean Particle Size d50 (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type L</td>
<td>70-100</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>50-70</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-50</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Type M</td>
<td>70-100</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>50-70</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-50</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
8. Granular Riprap Bedding:
   a. 3/4” – 1” Crushed rock – AASHTO 57/67

<table>
<thead>
<tr>
<th>Sieve Size (Inch)</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>3/4”</td>
<td>90-100</td>
</tr>
<tr>
<td>1/2”</td>
<td>25-60</td>
</tr>
<tr>
<td>3/8”</td>
<td>20-55</td>
</tr>
<tr>
<td>NO. 4</td>
<td>0-10</td>
</tr>
<tr>
<td>NO. 8</td>
<td>0-5</td>
</tr>
<tr>
<td>NO. 200</td>
<td>0-2</td>
</tr>
</tbody>
</table>

D. Pipe Bedding:
   1. Refer to Section 31 00 00 – Earthwork
   2. Minimum 6 inch deep, unless specified otherwise

E. Drainage Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
   1. Grab Tensile Strength: 110 lbf (490 N); ASTM D 4632.
   2. Tear Strength: 40 lbf (178 N); ASTM D 4533.
   3. Puncture Resistance: 50 lbf (222 N); ASTM D 4833.
   4. Water Flow Rate: 150 gpm per sq. ft. (100 L/s per sq. m); ASTM D 4491.
   5. Apparent Opening Size: No. 50 (0.3 mm); ASTM D 4751.

PART 3 EXECUTION

3.1 REGULATORY REQUIREMENTS

A. Comply with Town of Berthoud standards and specifications for public storm sewer installation.

3.2 PIPE PREPARATION

A. Shape trench and place bedding as specified in Section 31 00 00 and as shown on the drawings.
   1. Dig bell or coupling holes
   2. Do not support pipe on blocks or mounds of earth.
   3. Provide uniform and continuous bearing and support for full length of pipe between bell holes
   4. Minor disturbance over a maximum length of 18 inches near the middle of each length of pipe will be permissible by the withdrawal of pipe slings or other lifting tackle

B. Alignment and Grade
   1. Except as indicated on the Drawings, lay all pipe straight and at a uniform grade.
   2. Use batter boards to determine and check pipe subgrades.
   3. Other methods of maintaining alignment and grade may be acceptable if approved by the Engineer.
3.3 PIPE INSTALLATION

A. Inspect pipe and accessories for defects before lowering into trench.

B. Replace any defective, damaged or unsound pipe.

C. Carefully lower pipe, fittings, and accessories into the trench with derricks, ropes, and other suitable equipment to prevent damage. Do not dump or drop pipe or accessories into trench.

D. Pipe embedment shall be as specified in Section 31 00 00 for pipe.

E. Protect from lateral displacement by placing the specified pipe embedment material.

F. Do not lay pipe in water, under unsuitable weather conditions or under unsuitable trench conditions

G. Joint to form true and smooth line.

H. Remove any pipe not making a good fit.

I. Begin pipe laying at the lowest point unless reverse laying is accepted by Engineer.

J. Utilize implements, tools and facilities as recommended by the manufacturer and/or catch basins if required to remove debris.

K. Keep pipe clean during and after laying.

L. During construction, close all open ends with watertight expandable type plugs.
   1. At the end of each day’s operations.
   2. Whenever pipe ends are left unattended.
   3. Deposit adequate backfill on pipe to prevent flotation.
   4. Do not use wood, burlap or other similar temporary plugs.

M. Remove and re-lay any pipe which has floated.

3.4 PRECAST STRUCTURE PREPARATION

A. Verify items provided by other section of Work are properly sized and located

B. Verify that built-in items are in proper location, ready for roughing into Work

C. Verify excavation for manholes is correct

D. Excavation and Backfill: Refer to Section 31 00 00 - Earthwork for requirements

E. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections

F. Rock Subbase: Remove water, excavate, and place 1-1/2 inch washed rock 6-inch minimum depth, vibrate for compaction

3.5 CATCH BASINS

A. Construct catch basins to the sizes and shapes indicated, and to conform to requirements of authorities having jurisdiction.
1. Rock Subbase: Remove water, excavate, and place 1-1/2 inch washed rock 6-inch minimum depth, vibrate for compaction
2. For precast units, set in place to accurate elevations on firm, solid bed, plumb and level.
3. Pipe openings, elevations and alignment per plans
4. Seal and grout all pipe penetrations
5. Set cast iron frames and gratings to the elevations indicated.

3.6 PLACING MANHOLE SECTION OR CAST-IN PLACE BASE

A. Rock Subbase: Remove water, excavate, and place 1-1/2 inch washed rock 6-inch minimum depth, vibrate for compaction

B. Place base pad, trowel top surface level to accept manhole section with uniform bearing all around

C. Place sufficient non-shrink grout on base to ensure watertight fit between first manhole section and base or place first manhole section directly in wet concrete

D. Place manhole sections plumb and level, trim to correct elevations

E. Clean ends of sections and place double mastic gasket

F. Fill inside and outside of joint completely with non-shrink grout and trowel smooth

G. Cure non-shrink grout using approved methods

H. Set cover rings and covers level without tipping, to correct elevations or set cover rings and covers with slight tip to match cross slope of finished surface where directed by Engineer

I. Completed manholes shall be rigid and watertight

J. Coordinate with other sections of work to provide correct size, shape, and location

3.7 PREFORMED GASKETS

A. Remove and replace manhole sections which have chipped or cracked joints

B. Thoroughly clean section joints

C. Install gasket in conformance with manufacturer's recommendations

D. Only use primer furnished by gasket manufacturer

3.8 MANHOLE INVERT

A. Place concrete in bottom of manhole and form smooth transition. Trowel smooth and brush for non-skid finish. Slope bench 1 inch per foot for drainage to invert.

B. Invert shape to conform to radius of pipe it connects

C. Remove all rough sections or sharp edges which tend to obstruct flow or cause material to snag. Remove all grout droplets from invert

D. Construct in conformance with standard drawings
3.9 MANHOLE RINGS AND COVERS

A. Place rings in bed of non-shrink grout on top of manholes
B. Ensure no infiltration will enter manhole at this location
C. Carry non-shrink grout over flange of ring
D. Set top of ring flush with all surfaces subject to foot and vehicular traffic
E. Set top of ring 6 inches above surfaces in open, unraveled, non-pedestrian areas
F. Use precast grade rings for height adjustment

3.10 CONNECTION TO EXISTING MANHOLES

A. Maintain flow at all times
B. Prior approval of proposed method for maintaining flow must be obtained from Engineer
C. Cover area around new pipe with non-shrink grout and or waterstop gasket to ensure a watertight structure
D. Make connection during low flow periods

3.11 GROUT

A. PREPARATION
   1. Non-Shrink, Non-Metallic Grout, General Use
      a. Clean concrete surface to receive grout
      b. Saturate concrete with water for 24 hrs prior to grouting and remove excess water just prior to placing grout
      c. Cold weather conditions
         i) Warm concrete, substrate and base plate to 40 deg F, or above; store grout in warm area
         ii) Follow manufacturer's recommendations for cold weather application
      d. Hot weather conditions
         i) Use cold mixing water and cool base plate if possible; store grout in cool area
         ii) Follow manufacturer's recommendations for hot weather application
      e. Apply to clean, sound surface
      f. Apply latex bonding agent to hardened concrete, mix-in-grout, or as directed by Engineer
   2. Epoxy Grout: Apply only to clean, dry, sound surface
      a. Patching cavities in concrete including, but not limited to, tie holes, and structural and equipment support

B. APPLICATION
   1. Non-Shrink, Non-Metallic Grout
      a. Mix in a mechanical mixer
      b. Use no more water than necessary to produce flowable grout
      c. Provide air vents where necessary to eliminate air pockets
      d. Place in accordance with manufacturer’s instructions
      e. Where exposed to view finish grout edges smooth
      f. Protect against rapid moisture loss by immediately covering with wet rags and polyethylene sheets or curing compound
      g. Wet cure grout for 7 days, minimum
h. Maintain the temperature at a minimum of 40 deg F until grout reaches 3000 psi
i. After placement of grout, eliminate excessive external vibration

2. Epoxy Grout
   a. Mix and place in accordance with manufacturer's instructions
   b. Completely fill all cavities and spaces around dowels and anchors without voids
   c. Obtain manufacturer's technical assistance as required to insure proper placement

3.12 RIPRAP
   A. Do not place riprap over frozen or spongy subgrade surfaces.
   B. Place riprap at pipe outlets and in channels as indicated on plans. Top of riprap to match invert of outlet pie and channels.
   C. Excavate and prepare subgrade.
   D. Place geotextile fabric per plans under all bedding. Place bedding and place riprap on bedding per plans.
   E. Material may be machine placed and then arranged as necessary by use of a Gradall with multi-prong grapple device or by hand to minimize voids. Dumping alone is not sufficient to achieve properly placed riprap.

3.13 FIELD QUALITY CONTROL
   A. Field inspection and testing including a lamp test will be performed for every section of pipe after backfill has occurred
      1. Contractor shall furnish suitable assistance to the Engineer
      2. A minimum of 75% of a true circle will be required to indicate a properly constructed line
      3. Contractor will repair any section not passing the lamp test.
   B. Request inspection immediately after placing cover over pipe.
   C. Backfilling and testing as required per Section 31 00 00 - Earthwork.

END OF SECTION