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SECTION 211000 - WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Wet-pipe sprinkler systems.

B. Related Sections include the following:
   1. Division 10 Section "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
   2. Division 22 Section "Facility Water Distribution Piping" for piping outside the building.
   3. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

C. All black steel sprinkler pipe shall have a wall thickness less than or equal to schedule 40 and greater than schedule 10.
   1. Exception: Pipe with a nominal pipe size of 6 inches and greater may be schedule 10.

D. Summary Table:

<table>
<thead>
<tr>
<th>Item</th>
<th>Summary</th>
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<tbody>
<tr>
<td>Underground service entrance</td>
<td>Ductile Iron, restrained as required, with thrust blocks,</td>
</tr>
<tr>
<td>piping</td>
<td>transitioned with bolted flange.</td>
</tr>
<tr>
<td>Interior pipe type</td>
<td>Mains: Schedule 40</td>
</tr>
<tr>
<td>Sprinkler Finish</td>
<td>Branchlines: Threadable thinwall or schedule 40</td>
</tr>
<tr>
<td>Extended Coverage</td>
<td>Flat Plate Concealed, except uprights and storage</td>
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<td>Center of Tile</td>
<td>Not Allowed</td>
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<td>Flexible Sprinkler Drops</td>
<td>Required, Center thirds are acceptable for rectangular tiles</td>
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<td>Calculations</td>
<td>Designers preference</td>
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<tr>
<td>Alarm Device</td>
<td>Required, use reduced flow data</td>
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<tr>
<td>FDC</td>
<td>Horn/Strobe</td>
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<tr>
<td></td>
<td>Flush Polished Brass 2-inlet</td>
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<tr>
<td></td>
<td>Caps: Knox required purchased by contractor, coordinate</td>
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<tr>
<td></td>
<td>installation with local Fire Department</td>
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</table>
1.3  DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. High-Pressure Piping System: Fire-suppression piping system designed to operate at working pressure higher than standard 175 psig.

D. PE: Polyethylene plastic.

E. Underground Service-Entrance Piping: Underground service piping below the building.

1.4  SYSTEM DESCRIPTIONS

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

1.5  PERFORMANCE REQUIREMENTS


B. Design sprinkler piping according to the following and obtain approval from engineer, prior to submitting to other authorities having jurisdiction:

1. Design sprinkler system with the following 10% reduced flow data:

   Flow data available at 300 N and 400 W Logan UT

   Static – 88psi

   Residual – 79psi @ 2251gpm flowing

   Date of Test – 10/03/2019 by VBFA, Inc.

2. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.

3. Sprinkler Occupancy Hazard Classifications:

   a. Building Service Areas: Ordinary Hazard, Group 1.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   e. Library Stack Areas: Ordinary Hazard, Group 2.
   f. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   g. Office and Public Areas: Light Hazard.

4. Minimum Density for Automatic-Sprinkler Piping Design:
a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
d. Special Occupancy Hazard: As determined by authorities having jurisdiction.

5. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.

6. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

7. Sprinklers are to be installed throughout the premises, as required by NFPA 13.

C. Seismic Performance: Fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13.

1.6 SUBMITTALS

A. Product Data: For the following:
   1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
   2. Pipe hangers and supports, including seismic restraints.
   3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
   4. Air compressors, including electrical data.
   5. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
   6. Hose connections, including size, type, and finish.
   7. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
   8. Alarm devices, including electrical data.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Fire-hydrant flow test report.

D. Seismic Calculations.

E. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable. Drawings are to be approved by Engineer prior to submission to State Fire Marshal.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's
Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

G. Welding certificates.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project and obtained design approval and inspection approval from authorities having jurisdiction. The Engineer requires evidence to support the ability of the contractor to perform work in the scope and volume as specified. A contractor, who cannot show such experience, may be found not suitable to perform the work. The following are the approved contractors for this project:

a. PRE-APPROVED CONTRACTORS LIST
   1) Alta Fire
   2) Certified Fire
   3) Chaparral Fire
   4) Delta Fire
   5) Kimco Fire
   6) Paradise Fire
   7) Preferred Fire Protection
   8) Quality Fire Protection
   9) Fire Services Inc.
   10) FireTrol
   11) FireFly Fire Protection
   12) Simplex-Grinnell
   13) State Fire DC Specialties
   14) The Safety Team
   15) Western Automatic
   16) Or prior approved equal

b. A contractor not listed in the "PRE-APPROVED CONTRACTORS LIST" must receive prior approval from the engineer to bid this project.

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

1. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer or NICET Level III technician.

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

D. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

E. International Conference of Building Code Officials codes and standards complying with the following:

2. IFC-2018, "International Fire Code."

F. Utah Amendments
   1. Title 15A

1.8 COORDINATION

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

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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

1.10 General Engineering Quality

A. Unless noted otherwise the following applies:
   1. The maximum water velocity shall not exceed 32-fps.
   2. Submit the calculations using the reduced flow data.
   3. When calculating flexible drops, the contractor shall use the maximum number of bends for the associated length. The value is to be taken from the UL tests (unless the material is only FM approved).
   4. In the event of multiple (3) submittal rejections (including revise and resubmit) a meeting shall be held at the engineer’s office at the engineer time of choosing and the designer, fire sprinkler contractor, and general contractor shall be physically in attendance to discuss the required modifications to the design.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell end and plain end.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, Class 53, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland, rubber gasket, and steel bolts and nuts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

2.3 C-900 TUBE AND FITTINGS

A. PVC, AWWA Pipe: AWWA C900, Class 150, with bell end with gasket and spigot end.
   1. Comply with UL 1285 for fire-service mains if indicated.
   2. PVC Fabricated Fittings: AWWA C900, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
   3. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
   4. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   5. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.4 STAINLESS STEEL IN BUILDING RISER

A. Continuous from the factory, no field formed fittings in the stainless steel riser. Field modifications are not allowed. Restrain with thrust block, per NFPA 24, rods as required by manufacture.
   1. Inlet: AWWA C900/DIP
   2. Outlet: AWWA 606
2.5 STEEL PIPE AND FITTINGS

A. Threaded-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed threaded ends.

5. Steel Threaded Couplings: ASTM A 865 hot-dip galvanized-steel pipe where indicated.


1. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting not allowed.


2. Steel Flanges and Flanged Fittings: ASME B16.5.


1. Grooved-Joint Piping Systems:

   a. Manufacturers:

      1) Anvil International, Inc.
      2) Central Sprinkler Corp.
      3) Victaulic Co. of America.

   b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.

   c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

E. Threaded-End, Threadable, Thinwall Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 40 and greater than Schedule 10, and with factory- or field-formed threaded ends.

5. Steel Threaded Couplings: ASTM A 865.

F. Plain-End, Threadable, Thinwall Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 40 and greater than Schedule 10.
   1. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting not allowed.

G. Plain-End, Threadable, Thinwall Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 40 and greater than Schedule 10.
   2. Steel Flanges and Flanged Fittings: ASME B16.5.

H. Grooved-End, Threadable, Thinwall Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 40 and greater than Schedule 10, and with factory- or field-formed, roll-grooved ends.
   1. Grooved-Joint Piping Systems:
      a. Manufacturers:
         1) Anvil International, Inc.
         2) Central Sprinkler Corp.
         3) Victaulic Co. of America.
      b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
      c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

I. Plain-End, Schedule 10 Steel Pipe: ASTM A 135 or ASTM A 795, Schedule 10 is not allowed.

J. Plain-End, Nonstandard OD, Thinwall Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 10 is not allowed.

K. Plain-End, Hybrid Steel Pipe: ASTM A 135 or ASTM A 795, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5 is not allowed.

L. Grooved-End, Hybrid Steel Pipe: ASTM A 135 or ASTM A 795, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5; with factory- or field-formed, roll-grooved ends are not allowed.

M. Schedule 5 Steel Pipe: ASTM A 135 or ASTM A 795, lightwall, with plain ends is not allowed.

2.6 CPVC TUBE AND FITTINGS
   1. Not permitted on this project.
2.7 FLEXIBLE SPRINKLER DROPS

A. Flexible connectors shall be FM approved with exterior wire braid and have materials suitable for system fluid. Include 175-psig minimum working-pressure rating and ends according to the following:

   1. NPS 1: Threaded.

B. Manufacturers:

   1. Flex-Head
   2. Victaulic

C. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

D. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.

2.8 FLEXIBLE PIPE CONNECTORS (SEISMIC)

A. Flexible connectors shall be FM approved with exterior wire braid and have materials suitable for system fluid. Include 175-psig minimum working-pressure rating and ends according to the following:

   1. NPS 2 and Smaller: Threaded.
   2. NPS 2-1/2 and Larger: Flanged.
   3. Option for NPS 2-1/2 and Larger: Grooved for use with grooved-end-pipe couplings.

B. Manufacturers:

   1. Flexicraft Industries.
   2. Flex-Pression, Ltd.
   3. Metraflex, Inc.

C. Bronze-Hose, Flexible Connectors: Corrugated, bronze, inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to hose.

D. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

E. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.

2.9 CORROSION-PROTECTIVE ENCASEMENT FOR PIPING

A. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105, PE film, 0.008-inch minimum thickness, tube or sheet.
2.10 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be FMG approved with 175-psig minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 250-psig minimum working-pressure rating if fittings are components of high-pressure piping systems.

B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body, with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
   1. Manufactures:
      a. Central Sprinkler Corp.
      b. Fire-End and Croker Corp.
      c. Viking Corp.
      d. Victaulic Co. of America.

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

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

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

2.11 LISTED FIRE-PROTECTION VALVES

A. Valves shall be FMG approved, with 175-psig minimum pressure rating. Valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.

B. Gate Valves with Wall Indicator Posts:
   1. Gate Valves: UL 262, cast-iron body, bronze mounted, with solid disc, nonrising stem, operating nut, and flanged ends.
   2. Indicator Posts: UL 789, horizontal-wall type, cast-iron body, with hand wheel, extension rod, locking device, and cast-iron barrel.
   3. Manufacturers:
      b. McWane, Inc.; Kennedy Valve Div.
      c. NIBCO.
      d. Stockham.

C. Ball Valves: Comply with UL 1091, except with ball instead of disc.
   1. NPS 1-1/2 and Smaller: Bronze body with threaded ends.
   2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
   3. NPS 3: Ductile-iron body with grooved ends.
   4. Manufacturers:
      a. NIBCO.
b. Victaulic Co. of America.

D. Butterfly Valves: UL 1091.

1. NPS 2 and Smaller: Bronze body with threaded ends.
   a. Manufacturers:
      1) Global Safety Products, Inc.
      2) Milwaukee Valve Company.

2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
   a. Manufacturers:
      1) Central Sprinkler Corp.
      2) McWane, Inc.; Kennedy Valve Div.
      3) Mueller Company.
      4) NIBCO.
      5) Victaulic Co. of America.

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

1. Manufacturers:
   b. Central Sprinkler Corp.
   c. Clow Valve Co.
   d. Crane Co.; Crane Valve Group; Crane Valves.
   e. Crane Co.; Crane Valve Group; Jenkins Valves.
   f. Fivalco
   g. Globe Fire Sprinkler Corporation.
   h. Grinnell Fire Protection.
   i. Hammond Valve.
   j. McWane, Inc.; Kennedy Valve Div.
   k. Mueller Company.
   l. NIBCO.
   m. Potter-Roemer; Fire Protection Div.
   n. Reliable Automatic Sprinkler Co., Inc.
   o. Star Sprinkler Inc.
   p. Stockham.
   q. United Brass Works, Inc.
   r. Victaulic Co. of America.
   s. Watts Industries, Inc.; Water Products Div.

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

1. NPS 2 and Smaller: Bronze body with threaded ends.
   a. Manufacturers:
      1) Crane Co.; Crane Valve Group; Crane Valves.
2) Fivalco.
3) Hammond Valve.
4) NIBCO.
5) United Brass Works, Inc.

2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.

a. Manufacturers:

1) Clow Valve Co.
2) Crane Co.; Crane Valve Group; Crane Valves.
3) Crane Co.; Crane Valve Group; Jenkins Valves.
4) Fivalco
5) Hammond Valve.
6) Milwaukee Valve Company.
7) Mueller Company.
8) NIBCO.
9) United Brass Works, Inc.

G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.

1. Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch and Visual.
2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.

a. Manufacturers:

1) Milwaukee Valve Company.
2) NIBCO.
3) Victaulic Co. of America.

3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

a. Manufacturers:

1) Central Sprinkler Corp.
2) Grinnell Fire Protection.
3) McWane, Inc.; Kennedy Valve Div.
4) Milwaukee Valve Company.
5) NIBCO.
6) Victaulic Co. of America.

H. Supervised Normally Closed Valve

1. Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch and visual to send signal on partial close.

a. Manufactures:

1) NIBCO.
2) Victaulic Co. of America.
2.12 UNLISTED GENERAL-DUTY VALVES

A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.

D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.13 SPECIALTY VALVES

A. Sprinkler System Control Valves: FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.

1. Manufacturers:
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Victaulic Co. of America.
   d. Viking Corp.

B. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.

1. Manufacturers:

2.14 SPRINKLERS

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

B. Manufacturers:

2. Reliable Automatic Sprinkler Co., Inc.
3. Victaulic Co. of America.
4. Viking Corp.
5. Tyco Fire

C. Automatic Sprinklers: With heat-responsive element complying with the following:

1. UL 199, for nonresidential applications.

D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
E. Sprinkler types, features, and options as follows:
   1. Concealed ceiling sprinklers, including cover plate.
   2. Extended-coverage sprinklers, not allowed unless approved in writing prior to bidding.
   3. Flow-control sprinklers, with automatic open and shutoff feature.
   4. Flush ceiling sprinklers, including escutcheon, not allowed.
   5. Institution sprinklers, made with a small, breakaway projection.
   6. Pendent sprinklers.
   7. Pendent, dry-type sprinklers.
   8. Quick-response sprinklers.
   9. Recessed sprinklers, including escutcheon.
  10. Sidewall sprinklers.
  11. Sidewall, dry-type sprinklers.
  12. Upright sprinklers.

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

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

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   1. Ceiling Mounting: Flat plate concealed, white.

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

2.15 HOSE CONNECTIONS

A. Manufacturers:
   1. Central Sprinkler Corp.
   2. Elkhart Brass Mfg. Co., Inc.
   3. Fire-End and Croker Corp.
   4. Fivalco
   5. Grinnell Fire Protection.
   7. McWane, Inc.; Kennedy Valve Div.
   10. United Brass Works, Inc.

B. Description: UL 668, brass or bronze, 300-psig minimum pressure rating, hose valve for connecting fire hose. Include angle or gate pattern design; female NPS inlet and male hose outlet; and lugged cap, gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2, and hose valve threads according to NFPA 1963 and matching local fire department threads.
   1. Valve Operation: Nonadjustable type, unless pressure-regulating type is indicated.
   2. Finish: Rough metal.
2.16 FIRE DEPARTMENT CONNECTIONS

A. Manufacturers:

1. Central Sprinkler Corp.
2. Elkhart Brass Mfg. Co., Inc.
3. Fire-End and Croker Corp.
5. Guardian Fire Equipment Incorporated.
6. Potter-Roemer; Fire-Protection Div.
7. Reliable Automatic Sprinkler Co., Inc.
8. United Brass Works, Inc.

B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR."

   1. Type: Flush, with two inlets and square or rectangular escutcheon plate.
   2. Finish: Polished brass.

2.17 ALARM DEVICES

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

B. Electrically Operated Alarm: UL 464, with 8-inch- minimum- diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.

   1. Manufacturers:

      b. System Sensor.

C. Electrically Operated Alarm: Horn/Strobe, NEMA 3R minimum suitable for outdoor use.

   1. Manufacturers:

      b. System Sensor.

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

   1. Manufacturers:

      a. ADT Security Services, Inc.
      b. Grinnell Fire Protection.
      c. ITT McDonnell & Miller.
d. Potter Electric Signal Company.

e. System Sensor.

f. Viking Corp.

g. Watts Industries, Inc.; Water Products Div.

E. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.

1. Manufacturers:

   b. Potter Electric Signal Company.
   c. System Sensor.
   d. Viking Corp.

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

1. Manufacturers:

   a. McWane, Inc.; Kennedy Valve Div.
   b. Potter Electric Signal Company.
   c. System Sensor.

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

1. Manufacturers:

   b. System Sensor.

2.18 PRESSURE GAGES

A. Manufacturers:

   3. Marsh Bellofram.
   4. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 250 psig minimum.

   1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
   2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.
2.19 DOUBLE CHECK VALVE ASSEMBLIES

A. Manufacturers

1. Ames
2. Backflow Direct
3. Febco
4. Wilkins
5. Watts

B. Description; Resilient seated, spring loaded with testable outlets provided, as required by Authorities Having Jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Obtain Engineer’s Water Analysis or fire-hydrant flow test. Use results for system design calculations required in "Quality Assurance" Article in Part 1 of this Section.

B. Engineer’s Water Analysis. See Flow Analysis provided by Van Boerum & Frank Associates.

3.2 EARTHWORK

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

3.3 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

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

3.4 PIPING APPLICATIONS

A. Shop weld pipe joints where welded piping is indicated.

B. Do not use welded joints for galvanized-steel pipe.

C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system’s pressure rating may be used in aboveground applications, unless otherwise indicated.
D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

E. Underground Service-Entrance Piping: Ductile-iron, push-on or mechanical-joint pipe and fittings and restrained joints. Include corrosion-protective encasement.

F. Sprinkler Main Piping: Use the following:
   1. NPS 6 and Smaller: Standard-weight steel pipe with threaded ends, or grooved ends. No plain ends allowed.
   2. Outlets shall be welded.
      a. Victaulic Brand Mechanical tee fittings may be used in lieu of welded outlets.

G. Branch line piping: Use the following:
   1. NPS 2 and Smaller: Threadable steel pipe with threaded ends; cast- or malleable-iron threaded fittings; and threaded joints.
      a. Victaulic Brand Mechanical tee fittings may be used

H. Mains: Use the following:
   1. NPS 4 to NPS 6: Schedule 40 steel pipe with grooved ends & Welded outlets.
   2. NPS 3 and Smaller: Schedule 40 steel pipe with threaded ends, or grooved ends. No plain ends allowed.

3.5 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Fire-Protection-Service Valves: UL listed and FM approved for applications where required by NFPA 13 and NFPA 14.
   2. General-Duty Valves: For applications where UL-listed and FM-approved valves are not required by NFPA 13 and NFPA 14.
      a. Shutoff Duty: Use gate, ball, or butterfly valves.
      b. Throttling Duty: Use globe, ball, or butterfly valves.

3.6 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Result for HVAC" for basic piping joint construction.

B. Ductile-Iron-Piping, Grooved Joints: Use ductile-iron pipe with radius-cut-grooved ends; ductile-iron, grooved-end fittings; and ductile-iron, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
C. Steel-Piping, Grooved Joints: Use Schedule 40 steel pipe with cut or roll-grooved ends and Schedule 30 or thinner steel pipe with roll-grooved ends; steel, grooved-end fittings; and steel, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions. Use gaskets listed for dry-pipe service for dry piping.

3.7 WATER-SUPPLY CONNECTION

A. Install shutoff Backflow preventions assemblies, valve, pressure gage’s, drain, and other accessories at connection to water service.

3.8 PIPING INSTALLATION

A. Refer to Division 23 Section "Common Work Result for HVAC" for basic piping installation.

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

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

C. Install underground service-entrance piping according to NFPA 24 and with restrained joints.

D. Install all new underground service-entrance piping with restrained joints, hydrants, and post indicator valves per FM Global Data Sheet 3-10.

E. Make connections between underground and above-ground piping using bolted flange.

F. Install mechanical sleeve seal at pipe penetrations in basement and foundation walls. Refer to Division 23 Section "Common Work Result for HVAC."

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

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

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

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

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

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

M. Install alarm devices in piping systems.

N. Hangers and Supports: Comply with NFPA 13 for hanger materials.
1. No powder driven studs allowed.
2. Wrap-around braces are to be provided at end of branch lines.

O. Earthquake Protection: Install piping according to NFPA 13-9.3 requirements, to protect from earthquake damage. Seismic Bracing shall be designed to withstand vertical forces and movement.

P. Install piping with grooved joints according to manufacturer's written instructions. Construct rigid piping joints, unless otherwise indicated, or required by NFPA 13 for flexibility in seismic zones.

Q. Install pressure gages on riser or feed main, at each sprinkler test connection. 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 will not be subject to freezing.

R. When a fire pipe crosses a seismic expansion joint it shall have a Metraflex fire loop installed at the joint in accordance with NFPA 13 chapter 9.

3.9 SPECIALTY SPRINKLER FITTING INSTALLATION

A. Install specialty sprinkler fittings according to manufacturer's written instructions.

3.10 VALVE INSTALLATION

A. Refer to Division 23 Section "Valves" for installing general-duty valves. Install fire-protection specialty valves, trim, fittings, controls, and specialties according to NFPA 13 and NFPA 14, manufacturer's written instructions, and authorities having jurisdiction.

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

C. Double Check Valve Assemblies: Install valves in vertical up or horizontal position, per listings and for proper direction of flow.

3.11 SPRINKLER APPLICATIONS

A. General: All sprinklers are to be quick response type. Sprinkler heads shall be of the latest design closed spray type for 155°F unless specified otherwise or required by code. Extended coverage heads shall not be used. Orifices larger than 1/2" may be used as required by density and spacing demands. Use sprinklers according to the following applications:

1. Rooms without Ceilings: Upright and/or pendent sprinklers. Provide mechanical guards on all heads at or below 7'-0" height above the floor or where damage from room occupant use may occur.
2. Rooms with Ceilings: Concealed sprinklers, where indicated.
4. Institutional sprinklers shall be installed in areas of detention, correctional or mental health care facilities.
5. Spaces Subject to Freezing: Upright; pendent, dry-type; and sidewall, dry-type sprinklers.
6. Provide freeze proof type automatic sprinkler heads serving unconditioned spaces, areas subject to freezing and in other areas requiring their use.
7. Heads located within the air streams of unit heaters or other heat-emitting equipment shall be selected for proper temperature rating.
8. Sprinkler Finishes: Use sprinklers with the following finishes:
   a. Upright, Pendent, and Sidewall Sprinklers: Chrome in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view.
   b. Concealed Sprinklers: Rough brass, with White cover plate to match ceiling color.

B. Sprinklers: Use the following:
   1. All sprinklers shall be listed, quick response type.
   2. Sprinkler in future finish spaces (shelled) 10’ x 10’ spacing shall be pendants/uprights installed with 1 x ½” bushing, to accommodate future finishes.

3.12 SPRINKLER INSTALLATION

A. Every effort shall be required to ensure that the heads form a symmetrical pattern in the ceiling with the ceiling grid, lights, diffusers and grilles. Offsets shall be made in piping to accommodate ductwork in the ceiling. Heads should be symmetrical and all piping run parallel or perpendicular to building lines.
   1. In no case shall sprinkler heads be installed closer than approved distances from ceiling obstructions and HVAC ductwork.
   2. Sprinkler heads shall not conflict with tile grids.
   3. Sprinkler heads shall be located near center of corridors.

B. Where layout of sprinkler heads is shown on reflected ceiling plans the locations shall be followed unless approval is obtained from the Architect or such locations shown do not meet the requirements of NFPA-13. In either case, approval of the Architect shall be obtained in writing before sprinkler head locations are changed. If the installation of additional heads is needed to conform to NFPA 13 requirements in areas where heads are shown on reflected ceiling plans, they shall be included in the contract price.

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

D. Future finish shelled and tenant finish; Shell spaces shall be piped to accommodate future. Install sprinklers with 1” x ½” bushings, and space heads at a maximum spacing of 100 sq. ft. per head. Occupancy shall be Ordinary-Hazard Group 1 Design.

E. Concealed type sprinkler shall be installed in the following areas:
   1. Throughout
3.13 FIRE DEPARTMENT CONNECTION INSTALLATION
A. When installing the Fire Department Connection, the contractor is to ensure that there are no permanent obstruction(s) as to the fire department access. If an obstruction is present immediately notify the designer and the design team before proceeding with the installation.
B. Coordinate the exact location with the Architect and the Authority Having Jurisdiction.
C. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

3.14 CONNECTIONS
A. Connect water-supply piping and sprinklers where indicated.
B. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
C. Electrical Connections: Power wiring is specified in Division 28.
D. Connect alarm devices to fire alarm.

3.15 LABELING AND IDENTIFICATION
A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Division 23 Section "Common Work Result for HVAC."

3.16 FIELD QUALITY CONTROL
A. Flush, test, and inspect sprinkler piping according to NFPA 13, "System Acceptance" Chapter.
B. Replace piping system components that do not pass test procedures and retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
C. When making a mechanical tee connection the coupon shall be attached at the mechanical tee.
D. Report test results promptly and in writing to Architect and authorities having jurisdiction.
E. Whether the underground serving the sprinkler system is done by this contractor or another, this contractor will be responsible to assure and have in his possession a certificate that the underground has been flushed and tested by the contractor who installed it in accordance with NFPA-24 prior to connection of the underground piping to the overhead sprinkler system.

3.17 CLEANING
A. Clean dirt and debris from sprinklers.
B. Remove and replace sprinklers having paint other than factory finish.
3.18 PROTECTION
   A. Protect sprinklers from damage until Substantial Completion.

3.19 COMMISSIONING
   A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.
   B. Verify that specified tests of piping are complete and that “Material Test Certificates” are complete.
   C. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.
   D. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.
   E. Verify that hose connections and fire department connections have threads compatible with local fire department equipment.
   F. Fill wet-pipe sprinkler piping with water.
   G. Verify that hose connections are correct type and size.
   H. Coordinate with fire alarm tests. Operate as required.

3.20 DEMONSTRATION & TESTS
   A. Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.
   B. All tests will be conducted as required by the local authority having jurisdiction, and in no case less than those required by NFPA standards. As a minimum, piping in the sprinkler system shall be tested at a water pressure at 200 psi for a period of not less two hours, or at 50 psi in excess of the normal pressure when the normal pressure is above 150 psi. Bracing shall be in place, and air shall be removed from the system through the hydrants and drain valves before the test pressure is applied. No apparent leaks will be permitted on interior or underground piping.
   C. The local jurisdiction having authority and the Utah State Fire Marshal's office (where required) shall be notified at least three working days in advance of all tests and flushing. This includes any flushing of underground, hydrostatic testing, or flow testing that may be required.
   D. This contractor shall make all the required tests to the sprinkler system as required by code. He shall be responsible to assure that the Contractor Test Certificates for the overhead, backflow and underground work are completed and delivered to the owner's insurance underwriter to assure proper insurance credit.
   E. All tests requiring the witnessing by local authorities will be the responsibility of this contractor. If tests are not run or do not have the proper witness, then they will be run later
and all damage caused by the system, or caused in uncovering the system for such test, will be borne by this contractor.

3.21 WARRANTY

A. This contractor shall warranty the sprinkler system and all its components for one year from the date of acceptance by the owner. Any costs incurred to extend any warranties of materials to assure this time frame shall be borne by this contractor.

B. Provide Operation and Maintenance Manuals with correct as-builds test certificates and warranties included. A minimum 6 sets to be provided in red 3-ring binders. Include a current adopted version of NFPA 25 softbound copy left with owner.

C. Electronic copy of AutoCAD as-built drawings shall also be provided on CD, with each O&M Manual.

3.22 FIELD QUALITY CONTROL

A. Flush, test and inspect sprinkler piping according to NFPA 13, “System Acceptance” Chapter.

B. Replace piping system components that do not pass test procedures and retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

END OF SECTION 211000
SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

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

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms, accessible pipe shafts, accessible plumbing chases and accessible tunnels.

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

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

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

F. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.
1.4 **SMITTALS**

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. Welding certificates.

1.5 **QUALITY ASSURANCE**

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

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

1.6 **DELIVERY, STORAGE, AND HANDLING**

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

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

1.7 **COORDINATION**

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

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

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

**PART 2 - PRODUCTS**

2.1 **MANUFACTURERS**

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

   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.
2.2 PIPE, TUBE, AND FITTINGS

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

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

2.3 JOINING MATERIALS

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

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

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

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

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

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

2.4 TRANSITION FITTINGS

A. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
   1. Manufacturers:
      b. Fernco, Inc.
      d. Plastic Oddities, Inc.
2.5 DIELECTRIC FITTINGS

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

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

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
   
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.
      g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   
   2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
   
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers:
   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Co., Inc.
   d. Victaulic Co. of America.

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

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

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

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

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

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

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

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

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

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
C. One-Piece, Floor-Plate Type: Cast-iron floor plate.

D. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

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

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

2.10 LINK SEAL

A. Link-Seal® Modular Seal Pressure Plates

1. Link-Seal® modular seal pressure plates shall be molded of glass reinforced Nylon Polymer with the following properties:
   a. Izod Impact - Notched = 2.05ft-lb/in. per ASTM D-256
      Flexural Strength @ Yield = 30,750 psi per ASTM D-790
      Flexural Modulus = 1,124,000 psi per ASTM D-790
      Elongation Break = 11.07% per ASTM D-638
      Specific Gravity = 1.38 per ASTM D-792

2. Models LS200-275-300-315 shall incorporate the most current Link-Seal® Modular Seal design modifications and shall include an integrally molded compression assist boss on the top (bolt entry side) of the pressure plate, which permits increased compressive loading of the rubber sealing element. Models 315-325-340-360-400-425-475-500-525-575-600 shall incorporate an integral recess known as a "Hex Nut Interlock" designed to accommodate commercially available fasteners to insure proper thread engagement for the class and service of metal hardware. All pressure plates shall have a permanent identification of the manufacturer’s name molded into it.
3. For fire and Hi-Temp service, pressure plates shall be steel with 2-part Zinc Dichromate Coating.
4. Link-Seal® Modular Seal Hardware: All fasteners shall be sized according to latest Link-Seal® modular seal technical data. Bolts, flange hex nuts shall be: 316 Stainless Steel per ASTM F593-95, with a 85,000 psi average tensile strength.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

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

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

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

3.2 SEISMIC REQUIREMENTS

A. Comply with SEI/ASCE 7 and with requirements for seismic seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

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

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

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.
L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
   f. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   g. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
   h. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

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

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

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

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

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

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

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

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

T. Verify final equipment locations for roughing-in.

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

3.4 PIPING JOINT CONSTRUCTION

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

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


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

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

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

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

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

3.5 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

3.7 PAINTING

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

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

3.8 CONCRETE BASES

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

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

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.

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

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

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

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

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

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

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.
3.11 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 220500
SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

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

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

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
   A. Comply with requirements in this Section except when the requirements in plumbing equipment schedules, other specification sections, drawing notes or in other contract documents are more stringent.
   B. Comply with NEMA MG 1 unless otherwise indicated.
   C. Comply with IEEE 841 for severe-duty motors.

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

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

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

C. Service Factor: **1.15**.

D. Rotor: Random-wound, squirrel cage.

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

F. Temperature Rise: Match insulation rating.

G. Insulation: **Class F**. 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.

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

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

2.5 SINGLE-PHASE MOTORS

A. Motors larger than **1/20 hp** shall be one of the following, to suit starting torque and requirements of specific motor application:

   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

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

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

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

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513
SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

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

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

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

PART 2 - PRODUCTS

2.1 SLEEVES
   A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
   B. Galvanized-Steel Wall Pipes: ASTM A 53, Schedule 40, with plain ends and welded steel collar; zinc coated.
   C. Galvanized-Steel-Pipe Sleeves: ASTM A 53, 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.

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

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

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

### 2.3 GROUT


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

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

D. Packaging: Premixed and factory packaged.

### PART 3 - EXECUTION

#### 3.1 SLEEVE INSTALLATION

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

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

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

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

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

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

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide **1/4-inch** annular clear space between sleeve and pipe or pipe insulation.

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

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

3.2 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.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

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

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

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

5. Interior Partitions:

END OF SECTION 220517
SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Escutcheons.

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

PART 2 - PRODUCTS

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

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to 2 inch (50mm), 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 with polished, chrome-plated finish.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with chrome-plated finish.
d. Bare Piping **2 inch** and Smaller at Wall and Floor Penetrations in Finished Spaces: **One-piece, cast-brass** type with polished, chrome-plated finish.
e. Bare Piping Larger than **2 inch** at Wall and Floor Penetrations in Finished Spaces: **One-piece, stamped-steel type with polished, chrome-plated finish**
f. Bare Piping **2 inch** and Smaller at Ceiling Penetrations in Finished Spaces: **One-piece, cast-brass** type with polished, chrome-plated finish.
g. Bare Piping Larger than **2 inch** at Ceiling Penetrations in Finished Spaces: **One-piece, stamped-steel type with polished, chrome-plated finish**
h. Bare Piping **2 inch** and Smaller in Unfinished Service Spaces: **One-piece, cast-brass** type with polished, chrome-plated or rough-brass finish.
i. Bare Piping Larger than **2 inch** in Unfinished Service Spaces: **One-piece, stamped-steel type with polished, chrome-plated**.
j. Bare Piping **2 inch** and Smaller in Equipment Rooms: **One-piece, cast-brass** type with polished, chrome-plated or rough-brass finish.

### 3.2 FIELD QUALITY CONTROL

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

END OF SECTION 220518
SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

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

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

1.3 INFORMATIONAL SUBMITTALS
A. Product certificates.

1.4 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ashcroft Inc.
   2. Ernst Flow Industries.
   3. Marsh Bellofram.
   8. REOTEMP Instrument Corporation.
   10. Trerice, H. O. Co.
   11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   12. Weiss Instruments, Inc.
   13. WIKA Instrument Corporation - USA.
   14. Winters Instruments - U.S.
15. Weksler


C. Case: Liquid-filled and sealed type(s); stainless steel with 5 inch nominal diameter.

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

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

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

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

H. Window: Plain glass or plastic.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

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

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

   a. Flo Fab Inc.
   b. Miljoco Corporation.
   d. Tel-Tru Manufacturing Company.
   e. Trerice, H. O. Co.
   f. Weiss Instruments, Inc.
   g. Winters Instruments - U.S.
   h. Weksler


3. Case: Cast aluminum 7-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.

5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.

7. Window: Glass or plastic.

8. Stem: Aluminum and of length to suit installation.

   a. Design for Thermowell Installation: Bare stem.

10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 THERMOWELLS

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

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

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
      a. AMETEK, Inc.; U.S. Gauge.
      b. Ashcroft Inc.
      c. Ernst Flow Industries.
      d. Flo Fab Inc.
      e. Marsh Bellofram.
      f. Miljoco Corporation.
      g. Noshok.
      h. Palmer Wahl Instrumentation Group.
      i. REOTEMP Instrument Corporation.
      j. Tel-Tru Manufacturing Company.
      k. Treince, H. O. Co.
      l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
      m. Weiss Instruments, Inc.
      n. WIKA Instrument Corporation - USA.
      o. Winters Instruments - U.S.
      p. Weksler
   3. Case: Liquid-filled Open-front, pressure relief type(s); cast aluminum or drawn steel; 4-
      1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
9. Window: Glass or plastic.
10. Ring: Metal or Brass.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACH TEST PLUGS

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

1. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Weksler.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

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

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20 to 200 deg F shall be CR.
2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

2.6 ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston porous-metal-type surge-dampening device. Include extension for use on insulated piping.
B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid one-third of pipe diameter to center of pipe and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

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

G. Install valve and snubber in piping for each pressure gage for fluids.

H. 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.

I. 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.

J. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

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

L. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

M. Install test plugs in tees in piping.

N. Install permanent indicator on walls or brackets in accessible and readable positions.

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
1. Liquid-filled Sealed, bimetallic-actuated type.
2. Industrial-style, liquid-in-glass type.

B. Thermometers at inlets and outlets of each domestic water heat exchanger shall be one of the following:
   1. Liquid-filled Sealed, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:
   1. Liquid-filled Sealed, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

D. Thermometer stems shall be of length to match thermowell insertion length.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 150 deg F and minus 20 to plus 70 deg C.

B. Scale Range for Domestic Hot-Water Piping: 20 to 240 deg F and 0 to 150 deg C.

3.4 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be one of the following:
   1. Liquid-filled Sealed Open-front, pressure-relief, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:
   1. Liquid-filled Sealed Open-front, pressure-relief, direct mounted, metal case.

C. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:
   1. Liquid-filled Sealed Open-front, pressure-relief, direct-mounted, metal case.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping 0 to 160 psi and 0 to 1100 kPa.

B. Scale Range for Domestic Water Piping: 0 to 160 psi and 0 to 1100 kPa.

END OF SECTION 220519
SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Bronze ball valves.
4. Bronze lift check valves.
5. Bronze swing check valves.
7. Bronze globe valves.
8. Iron globe valves.

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene copolymer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.
F. RS: Rising stem.
G. SWP: Steam working pressure.
1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 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. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

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

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

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve.
   b. Milwaukee Valve Company.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze, or aluminum.

2.3 BRONZE BALL VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Hammond Valve.
   e. Lance Valves; a division of Advanced Thermal Systems, Inc.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

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

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Lance Valves; a division of Advanced Thermal Systems, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

C. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

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

b. DynaQuip Controls.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Red-White Valve Corporation.
2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

D. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hammond Valve.
      c. Milwaukee Valve Company.
      d. NIBCO INC.

   2. Description:
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Three piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

2.4 IRON, SINGLE-FLANGE BUTTERFLY VALVES

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

      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
         b. Conbraco Industries, Inc.; Apollo Valves.
         c. Cooper Cameron Valves; a division of Cooper Cameron Corporation.
         d. Crane Co.; Crane Valve Group; Jenkins Valves.
         e. Crane Co.; Crane Valve Group; Stockham Division.
         f. DeZurik Water Controls.
         g. Flo Fab Inc.
         h. Hammond Valve.
         i. Kitz Corporation.
         j. Milwaukee Valve Company.
         k. NIBCO INC.
l. Norriseal; a Dover Corporation company.
m. Red-White Valve Corporation.
n. Spence Strainers International; a division of CIRCOR International, Inc.
o. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

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

B. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corporation.
e. Crane Co.; Crane Valve Group; Center Line.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Milwaukee Valve Company.
l. Mueller Steam Specialty; a division of SPX Corporation.
m. NIBCO INC.
n. Norriseal; a Dover Corporation company.
o. Spence Strainers International; a division of CIRCOR International, Inc.
p. Sure Flow Equipment Inc.
q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

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

C. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corporation.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Milwaukee Valve Company.
l. Mueller Steam Specialty; a division of SPX Corporation.
m. NIBCO INC.
n. Norriseal; a Dover Corporation company.
o. Red-White Valve Corporation.
q. Sure Flow Equipment Inc.
r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

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

2.5 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
e. Ends: Threaded.
f. Disc: Bronze.

2.6 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Red-White Valve Corporation.
   k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   l. Zy-Tech Global Industries, Inc.

2. 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 150, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corporation.
   i. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.7 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Powell Valves.
   i. Red-White Valve Corporation.
   j. Sure Flow Equipment Inc.
   k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   l. Zy-Tech Global Industries, Inc.

2. 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.

B. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 500 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.

2.8 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Red-White Valve Corporation.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   j. Zy-Tech Global Industries, Inc.

2. 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.

2.9 **IRON GLOBE VALVES**

A. Class 125, Iron Globe Valves:

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

      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
      d. Hammond Valve.
      e. Kitz Corporation.
      f. Milwaukee Valve Company.
      g. NIBCO INC.
      h. Powell Valves.
      i. Red-White Valve Corporation.
      j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      k. Zy-Tech Global Industries, Inc.

   2. 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.

B. Class 250, Iron Globe Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 500 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
   B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
   C. Examine threads on valve and mating pipe for form and cleanliness.
   D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
   E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION
   A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
   B. Locate valves for easy access and provide separate support where necessary.
   C. Install valves in horizontal piping with stem at or above center of pipe.
   D. Install valves in position to allow full stem movement.
   E. Install check valves for proper direction of flow and as follows:
1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

### 3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

### 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball or butterfly valves.
3. Throttling Service Globe, angle, ball or butterfly valves.
4. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or check valves.
   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 classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

### 3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125 or Class 150, bronze disc.
3. Ball Valves: One, Two or Three piece, full or, regular port, bronze with bronze or stainless-steel trim.
4. Bronze Swing Check Valves: Class 125 or Class 150, bronze disc.
5. Bronze Globe Valves: Class 125 or Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Ball Valves: One, Two or Three piece, full or, regular port, bronze with bronze or stainless-steel trim.
4. Iron Swing Check Valves: Class 125 or Class 250, metal seats.
5. Iron Globe Valves: Class 125 or Class 250.

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SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe positioning systems.
8. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
3. Division 22 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
4. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 SEISMIC REQUIREMENTS

A. Component Importance Factor. All plumbing components shall be assigned a component importance factor. The component importance factor, I_p, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake.
2. The component contains hazardous materials.
3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

B. All other components shall be assigned a component importance factor, \( I_p \), equal to 1.0.

1.5 PERFORMANCE REQUIREMENTS

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

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

C. Seismic Performance: Plumbing equipment, hangers and supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 and with the requirements specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment.

1. For components with a seismic importance factor of 1.0 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."

2. For components with a seismic importance factor of 1.5 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

1.6 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.
4. Pipe positioning systems.
5. Mechanical Anchors: ICC-ES Evaluation Reports validating ‘Cracked Concrete’ testing per A.C. 193 must be provided for anchors resisting seismic loads and/or supporting life-safety systems including fire sprinkler systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Pipe stands. Include Product Data for components.
4. Equipment supports.

C. Welding certificates.

D. Delegated-Design Submittal:
1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment
guides, hangers and supports for multiple pipes, expansion joints and loops, and
attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior
walls, floors, basement, and foundation walls.
4. Seismic calculations and detailed analysis: Indicate fabrication and arrangement. Detail
attachments of restraints to the restrained items and to the structure. Show attachment
locations, methods, and spacings. Identify components, list their strengths, and indicate
directions and values of forces transmitted to the structure during seismic events.
Indicate association with vibration isolation devices. Project specific design
documentation and calculations shall be prepared and stamped by a registered
professional engineer who is responsible for the seismic restraint design and who is
licensed in the state where the project is being constructed (ASCE 7, 13.2.1.1).

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding
Code--Steel.", AWS D1.4, "Structural Welding Code--Reinforcing Steel." and ASME Boiler
and Pressure Vessel Code: Section IX.

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to
   Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support
types.

B. Manufacturers:

   1. Anvil International.
   2. AAA Technology & Specialties Co., Inc.
5. Carpenter & Paterson, Inc.
6. Empire Industries, Inc.
7. ERICO/Michigan Hanger Co.
8. FNW/Ferguson Enterprises
10. Grinnell Corp.
11. GS Metals Corp.
13. PHD Manufacturing, Inc.
14. PHS Industries, Inc.
15. Piping Technology & Products, Inc.
16. Tolco Inc.
17. Simpson Strong-Tie Co.

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

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

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

B. Manufacturers:

1. Anvil International.
2. B-Line Systems, Inc.; a division of Cooper Industries.
3. ERICO/Michigan Hanger Co.; ERISTRUT Div.
4. FNW/Ferguson Enterprises
5. GS Metals Corp.
6. Hilti, Inc.
8. Thomas & Betts Corporation.
9. Tolco Inc.
10. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

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

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

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

2.6 FASTENER SYSTEMS

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

1. Manufacturers:

   a. Hilti, Inc.
   b. MKT Fastening, LLC.
   c. Powers Fasteners.
   d. Simpson Strong-Tie Co.

B. Mechanical-Expansion Anchors and Concrete Screws: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used. For anchors resisting seismic loads and/or supporting life-safety systems including fire sprinkler systems, Anchors shall have been tested for ‘Cracked Concrete’ per A.C. 193 per a valid ICC-ES Evaluation Report. Manufacturers with these anchors have been designated below with: ‘*’

1. Manufacturers:

   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
e. MKT Fastening, LLC.
f. Powers Fasteners.
g. Simpson Strong-Tie Co.

2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

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

1. Manufacturers:
   a. Anvil International.
   b. ERICO/Michigan Hanger Co.
   c. MIRO Industries.
   d. Unipure

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

1. Manufacturers:
   a. MIRO Industries.

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

1. Manufacturers:
   a. Anvil International.
   b. ERICO/Michigan Hanger Co.
   c. MIRO Industries.
   d. Portable Pipe Hangers.

3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:
   a. Anvil International.
   b. Portable Pipe Hangers.

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Manufacturers:
   2. HOLDRITE Corp.; Hubbard Enterprises.
   3. Samco Stamping, Inc.

2.9 EQUIPMENT SUPPORTS

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

2.10 MISCELLANEOUS MATERIALS

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

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

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

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

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

E. Use padded hangers for piping that is subject to scratching.
F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. 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 pipes not subject to expansion or contraction.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-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.
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 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 2 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 20, 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 not necessary.
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 not necessary.
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.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
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.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18 or Simpson Blue Banger Concrete insert with UL & FM approvals): 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.

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

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. 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 absorb 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 absorb 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 absorb 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.

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

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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

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

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

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

C. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing 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. Powder actuated fasteners shall not be used for seismic bracing attachments.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. For anchors resisting seismic loads and/or supporting life-safety systems including fire sprinkler systems, anchors shall have been tested for 'Cracked Concrete' per A.C. 193 and shall have a valid ICC-ES Evaluation Report.

G. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

H. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

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


K. 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.

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

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

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   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 inserts.

6. Insert Material: Length at least as long as protective shield.

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

### 3.3 EQUIPMENT SUPPORTS

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

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

C. Provide lateral bracing, to prevent swaying, for equipment supports. For applications where seismic bracing is required, ‘Cracked Concrete’ expansion anchors or concrete screws tested per A.C. 193 must be provided for seismic bracing anchorage where post-installed anchors are required.
3.4 METAL FABRICATIONS

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

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

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

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

3.5 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.

3.6 PAINTING

A. Touch Up: 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. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529
SECTION 220533 - HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes plumbing piping heat tracing for freeze prevention, domestic hot-water-temperature maintenance, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:
   1. Constant wattage.

1.3 SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
   1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY
A. When warranties are required, verify with Owner's counsel that special warranties stated in this Article are not less than remedies available to Owner under prevailing local laws. Coordinate with Division 01 Section "Product Requirements."
B. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONSTANT-WATTAGE HEATING CABLES

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

1. BH Thermal Corporation.
2. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
3. Delta-Therm Corporation.
4. Easy Heat Inc.
6. Pyrotenax; a division of Tyco Thermal Controls.
7. Raychem; a division of Tyco Thermal Controls.
8. Thermon Manufacturing Co.
9. Trasor Corp.

B. Heating Element: Pair of parallel No. 12 AWG, nickel-coated stranded copper bus wires with single-stranded resistor wire connected between bus wires. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight.

C. Electrical Insulating Jacket: Flame-retardant fluoropolymer.

D. Cable Cover: Stainless-steel braid, and polyolefin outer jacket with UV inhibitor.

E. Maximum Operating Temperature (Power On): 392 deg F.

F. Capacities and Characteristics:

1. Maximum Heat Output: Provide capacities and characteristics as noted on the drawings.

2.2 CONTROLS

A. Pipe-Mounting Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Division 22 Section "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
   2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:
   1. Snow and Ice Melting in Gutters and Downspouts: Constant-wattage heating cable.
   2. Freeze protection for roof drainage piping: Constant-wattage.

3.3 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating Cable Installation for Snow and Ice Melting in Gutters and Downspouts: Install in gutters and downspouts with clips furnished by manufacturer that are compatible with gutters, and downspouts.

C. Electric Heating Cable Installation for Freeze Protection for Piping:
   1. Install electric heating cables after piping has been tested and before insulation is installed.
   2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Division 22 Section "Plumbing Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   1. Test cables for electrical continuity and insulation integrity before energizing.
   2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

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

END OF SECTION 220533
SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following restraints and vibration isolation as defined in Section 230548 “Vibration Isolation and Seismic Controls for HVAC” for the following:

1. Plumbing Piping.
2. Plumbing Equipment.

PART 2 - PRODUCTS

2.1 (NOT USED)

PART 3 - EXECUTION

3.1 (NOT USED)

END OF SECTION 220548
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.
7. Ceiling grid

1.3 SUBMITTALS

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

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

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

D. Valve numbering scheme.

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

1.4 COORDINATION

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

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

C. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch 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-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: Black.

C. Background Color: Yellow.

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

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

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

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

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

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

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

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 STENCILS

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

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

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

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

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

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

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

2.7 CEILING GRID

A. Provide valve identification for all plumbing and med gas valves located above the ceiling on the ceiling grid below the valve.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

D. Pipe Label Color Schedule:

1. Low-Pressure, Compressed-Air Piping:

2. Medium-Pressure, Compressed-Air Piping:

3. Domestic Water Piping:

4. Sanitary Waste and Storm Drainage Piping:

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   c. Low-Pressure Compressed Air: 1-1/2 inches, round.
   d. High-Pressure Compressed Air: 1-1/2 inches, round.

2. Valve-Tag Color:
   c. Low-Pressure Compressed Air: Comply with ASME A13.1.
   d. High-Pressure Compressed Air: Comply with ASME A13.1.
3. Letter Color:

c. Low-Pressure Compressed Air: Comply with ASME A13.1.
d. High-Pressure Compressed Air: Comply with ASME A13.1.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 220553
SECTION 220719 - PLUMBING PIPING INSULATION.

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Storm-water piping exposed to freezing conditions.
   5. Roof drains and rainwater leaders.

1.3 DEFINITIONS:
A. Refer to Section 220500 “Common Work Results for Plumbing”.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties, equipment connections, and access panels.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For qualified Installer.
B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation
materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.8 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.9 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Insulation for below-ambient service requires a vapor-barrier.

C. Products shall not contain asbestos, lead, mercury, or mercury compounds.

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

E. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

F. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553:

   1. Type II and ASTM C 1290, Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

   2. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

I. Mineral-Fiber, Preformed Pipe Insulation:

   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000-Degree Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
2. Type I, 850 Deg F  
   Materials: Mineral or glass fibers bonded with a thermosetting resin. 
   Comply with ASTM C 547, Type I, Grade A. 
   a. **Without factory-applied jacket** with factory-applied ASJ-SSL. Factory-applied 
      jacket requirements are specified in "Factory-Applied Jackets" Article. 

J. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used 
   in preforming insulation to cover valves, elbows, tees, and flanges.

### 2.2 INSULATING CEMENTS

   1. Products: Subject to compliance with requirements, provide the following: 
      a. Ramco Insulation, Inc.; Super-Stik.

   1. Products: Subject to compliance with requirements, provide the following: 
      a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

### 2.3 ADHESIVES

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

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, provide one of the following: 
      a. Aeroflex USA, Inc.; Aeroseseal. 
      b. Armacell LLC; Armaflex 520 Adhesive. 
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller 
         Company; 85-75. 
      d. K-Flex USA; R-373 Contact Adhesive. 
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when 
      calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following: 
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller 
         Company; CP-127. 
      b. Eagle Bridges - Marathon Industries; 225. 
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller 
         Company; 85-60/85-70. 
      d. Mon-Eco Industries, Inc.; 22-25. 
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when 
      calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone.
   d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
b. Eagle Bridges - Marathon Industries; 501.
d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 570.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 550.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.

2.5 SEALANTS

A. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Johns Manville; Zeston.
      c. Proto Corporation; LoSmoke.
      d. Speedline Corporation; SmokeSafe.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: Color-code jackets based on system.
      a. White.
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
      c. RPR Products, Inc.; Insul-Mate.
      a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
c. 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].

d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper. [2.5-mil-thick polysurlyn].

e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. **Products:** Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

### 2.9 SECUREMENTS

**A. Staples:** Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

### 2.10 PROTECTIVE SHIELDING GUARDS

**A. Protective Shielding Pipe Covers:**

1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
   a. Engineered Brass Company.
   b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
   c. McGuire Manufacturing.
   d. Plumberex.
   e. Truebro; a brand of IPS Corporation.
   f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

**B. Protective Shielding Piping Enclosures:**

1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
   a. Truebro; a brand of IPS Corporation.
   b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

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

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

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

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation,
install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

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

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

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

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

8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.
3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

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

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

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

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

3.8 FIELD-APPLIED JACKET INSTALLATION

A. 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.

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

3.9 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. Insulation shall have a k value that meets the minimum requirements of the latest International Energy Conservation Code (IECC).

C. 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.
3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. **NPS 1-1/2 and Smaller**: Insulation shall be one of the following:
   a. Flexible Elastomeric:
      1) 1 inch thick
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I:
      1) 1 inch thick

2. **NPS 2 and Larger**: Insulation shall be one of the following:
   a. Flexible Elastomeric:
      1) 1-1/2 inches thick.
   b. Mineral-Fiber, Preformed Pipe Insulation:
      1) 1-1/2 inches thick.

B. Domestic Hot and Recirculated Hot Water:

1. **NPS 1-1/2 and Smaller**: Insulation shall be **one of** the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I:
      1) 1 inch thick.

2. **NPS 2 and Larger**: Insulation shall be **one of** the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I:
      1) 1-1/2 inches thick

C. Storm water and Overflow:

1. All Pipe Sizes: Insulation shall be **one of** the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be **one of** the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Mineral-Fiber, Blanket Insulation, Type I: 1 inch thick.
   c. Drain Manufacturer's Pre-formed bowl Insulation: 1 inch thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Storm water and Overflow:

1. All Pipe Sizes: Insulation shall be **one of** the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
3.12 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:
   1. None.
   2. **PVC:**
      a. White: 20 mils thick

D. Piping, Exposed:
   1. **PVC:**
      a. White: **30 mils thick**

3.13 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. Piping, Concealed:

   1. None.

D. Piping, Exposed:

   1. **Aluminum, Stucco Embossed:** 0.016 inch thick.

END OF SECTION 220719
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

B. Delegated-Design Submittal:
   1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
   2. Locations of pipe anchors and alignment guides and expansion joints and loops.
   3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

   1. Notify Construction Manager or owner no fewer than two days in advance of proposed interruption of water service.
PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

C. All piping shall be American made and tested; no import pipe will be permitted.

D. All exposed water supply piping in toilet rooms, custodial rooms and kitchens shall be chromium plated.

E. All piping installed in or passing through a plenum must be plenum rated, fire wrapped, or installed in a metal conduit.

2.2 COPPER TUBE AND FITTINGS

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

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L 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.

2.3 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-Profile, 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.


2.4 PP PIPE AND FITTINGS
A. PP Pipe: ASTM F 2389, SDR 7.4 and SDR 11.
B. PP Socket Fittings: ASTM F 2389.

2.5 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.
E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
F. PP Pipe and Fittings: Manufacturer’s recommended fusion-weld system.

2.6 TRANSITION FITTINGS
A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.
B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
C. Sleeve-Type Transition Coupling: AWWA C219.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cascade Waterworks Manufacturing.
      b. Dresser, Inc.; Piping Specialties Products.
      c. Ford Meter Box Company, Inc. (The).
      d. JCM Industries.
e. Romac Industries, Inc.
f. Smith-Blair, Inc.; a Sensus company.
g. Viking Johnson.

D. Plastic-to-Metal Transition Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   b. Harvel Plastics, Inc.
   c. Spears Manufacturing Company.

2. Description:
   a. CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
   b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

E. PP-to-Metal Transition Fittings:
1. Description:
   a. PP one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
   b. One end with threaded brass insert and one fusion-socket end.

F. Plastic-to-Metal Transition Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Colonial Engineering, Inc.
   b. NIBCO Inc.
   c. Spears Manufacturing Company.

2. Description:
   a. CPVC four-part union.
   b. Brass threaded end.
   c. Solvent-cement-joint plastic end.
   d. Rubber O-ring.
   e. Union nut.

2.7 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 Nipples and Waterways:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elster Perfection Corporation.
   b. Grinnell Mechanical Products; Tyco Fire Products LP.
   c. Matco-Norca.
d. Clearflow/Perfection Corp.
e. Precision Plumbing Products, Inc.
f. Victaulic Company.

3. Electroplated steel nipple or waterway complying with ASTM F 1545 or ANSI/NSF-61 Compliant.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene or LTHS.

PART 3 - EXECUTION

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

3.2 PIPING INSTALLATION
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
B. Polypropylene pipe in or passing through plenums must be fire wrapped or installed in a metal conduit.
C. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
D. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
E. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
F. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Division 22 Section "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Division 22 Section "Domestic Water Piping Specialties."
G. Install shutoff valve immediately upstream of each dielectric fitting.
H. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Division 22 Section "Domestic Water Piping Specialties."
I. Install domestic water piping level without pitch and plumb.
J. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
K. Install seismic restraints on piping. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

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

M. 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.

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

O. Install piping to permit valve servicing.

P. 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.

Q. Install piping free of sags and bends.

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

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

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

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

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

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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

D. Brazed Joints 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."

F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

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

H. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. Roll groove ends of pipe as specified. 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.

I. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.

3.5 DIELECTRIC FITTING INSTALLATION

Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
B. Dielectric Fittings for NPS 2 and Smaller: Use **dielectric nipples/waterways**.

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

D. Dielectric Fittings for NPS 5 and Larger: Use **dielectric nipples/waterways**.

### 3.6 HANGER AND SUPPORT INSTALLATION

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

B. Comply with requirements for pipe hanger, support products, and installation in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

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

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.
H. Install supports for vertical steel piping every 15 feet.
I. Install supports for vertical PP piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.
J. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code. Comply with requirements for connection sizes in Division 22 plumbing fixture Sections.
   3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

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

3.9 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.

3.10 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.
3.11 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. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

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

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

3.12 PIPING SCHEDULE

A. Some piping types and sizes mentioned in this section may not be used on this project.

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

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

D. All exposed water supply piping in toilet rooms, custodial rooms and kitchens shall be chromium plated.
E. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:
   1. Soft copper tube, ASTM B 88, Type K wrought-copper, solder-joint fittings; and brazed joints.

F. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

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

H. 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; cast- or wrought- copper, solder-joint fittings; and brazed joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball for piping NPS 3 and smaller. Use butterfly, with flanged ends for piping NPS 4 and larger.
   2. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly valves with flanged ends for piping NPS 2-1/2 and larger.

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

END OF SECTION 221116
SECTION 22119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated water mixing valves.
7. Outlet boxes.
8. Hose bibs.
9. Wall hydrants.
10. Drain valves.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Emergency Plumbing Fixtures" for water tempering equipment.
3. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. FEBCO; SPX Valves & Controls.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts Industries, Inc.; Water Products Div.
      h. Zurn Plumbing Products Group; Wilkins Div.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products, Inc.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. MIFAB, Inc.
      e. Prier Products, Inc.
      g. Woodford Manufacturing Company.
      h. Zurn Plumbing Products Group; Light Commercial Operation.
      i. Zurn Plumbing Products Group; Wilkins Div.
5. Finish: Chrome or nickel plated.

C. Pressure Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Toro Company (The); Irrigation Div.
      g. Zurn Plumbing Products Group; Wilkins Div.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   5. Accessories:
      a. Valves: Ball type, on inlet and outlet.

D. Spill-Resistant Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
   3. Operation: Continuous-pressure applications.
   4. Accessories:
      a. Valves: Ball type, on inlet and outlet.

2.2 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

B. Double-Check Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Flomatic Corporation.
   e. Watts Industries, Inc.; Water Products Div.
   f. Zurn Plumbing Products Group; Wilkins Div.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; [flanged] <Insert type> for NPS 2-1/2 and larger.
7. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

C. Beverage-Dispensing-Equipment Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   c. Zurn Plumbing Products Group; Wilkins Div.
3. Operation: Continuous-pressure applications.

D. Dual-Check-Valve Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Flomatic Corporation.
   e. Ford Meter Box Company, Inc. (The).
   f. Honeywell Water Controls.
   g. McDonald, A. Y. Mfg. Co.
   h. Mueller Co.; Water Products Div.
   i. Watts Industries, Inc.; Water Products Div.
   j. Zurn Plumbing Products Group; Wilkins Div.

3. Operation: Continuous-pressure applications.

E. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Lancer Corporation.
   3. Operation: Continuous-pressure applications.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators: (Direct Type)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Conbraco Industries, Inc.
      c. Honeywell Water Controls.
      e. Zurn Plumbing Products Group; Wilkins Div.
   4. Body: Bronze, provide chrome-plated finish if connected to chrome plated or stainless steel piping for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
6. **End Connections:** Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

**B. Water Control Valves: (Pilot type)**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. CLA-VAL Automatic Control Valves.
   b. Mifab Corp; Beeco.
   d. Watts Industries, Inc.; Watts ACV.
   e. Zurn Plumbing Products Group; Wilkins Div.

2. **Description:** Pilot-operation, diaphragm-type, single-seated main water control valve.

3. **Pressure Rating:** Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.

4. **Main Valve Body:** Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.

5. **End Connections:** Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

### 2.4 BALANCING VALVES

**A. Copper-Alloy Calibrated Balancing Valves:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   b. Flo Fab Inc.
   c. ITT Industries; Bell & Gossett Div.
   d. NIBCO INC.
   e. TAC Americas.
   f. Taco, Inc.
   g. Victaulic
   h. Watts Industries, Inc.; Water Products Div.

2. **Type:** Ball or Y-pattern globe valve with two readout ports and memory setting indicator.

3. **Body:** bronze.

4. **Size:** Same as connected piping, but not larger than NPS 2.

5. **Accessories:** Meter hoses, fittings, valves, differential pressure meter, and carrying case.

**B. Cast-Iron Calibrated Balancing Valves:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   b. Flo Fab Inc.
   c. ITT Industries; Bell & Gossett Div.
   d. NIBCO INC.
   e. TAC Americas.
2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
3. Size: Same as connected piping, but not smaller than NPS 2-1/2.

C. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Cash Acme.
   c. Conbraco Industries, Inc.
   d. Honeywell Water Controls.
   e. Leonard Valve Company.
   f. Powers; a Watts Industries Co.
   g. Symmons Industries, Inc.
   h. Taco, Inc.
   i. Watts Industries, Inc.; Water Products Div.
   j. Zurn Plumbing Products Group; Wilkins Div.

4. Type: Thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Lawler Manufacturing Company, Inc.
   c. Leonard Valve Company.
   d. Powers; a Watts Industries Co.
   e. Symmons Industries, Inc.

4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.

C. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. Honeywell Water Controls.
   d. Lawler Manufacturing Company, Inc.
   e. Leonard Valve Company.
   f. Powers; a Watts Industries Co.
   g. Watts Industries, Inc.; Water Products Div.
   h. Zurn Plumbing Products Group; Wilkins Div.

3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

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

2.7 OUTLET BOXES

A. Water Outlet Boxes ICE-1:

1. Basis of Design: Water-Tite model W9200HA 6” diameter outlet box with ¼ turn valve and water hammer arrestor.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. IPS Corporation.
   c. LSP Products Group, Inc.
d. Oatey.
e. Plastic Oddities; a division of Diverse Corporate Technologies.

4. Material and Finish: Enamel-steel or epoxy-painted-steel or plastic box and faceplate.
5. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
6. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.8 HOSE BIBBS

A. Hose Bibbs HB-1:
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.
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: 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.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants FWH-1:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Woodford Manufacturing Company.
   h. Zurn Plumbing Products Group; Light Commercial Operation.
   i. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
8. Operating Keys: Two with each wall hydrant.

2.10 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.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Josam Company.
      c. MIFAB, Inc.
      d. PPP Inc.
      e. Sioux Chief Manufacturing Company, Inc.
      g. Tyler Pipe; Wade Div.
      h. Watts Drainage Products Inc.
      i. Zurn Plumbing Products Group; Specification Drainage Operation.
   3. Type: Metal bellows or Copper tube with piston.
   4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

C. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

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

E. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

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

G. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

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

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

J. Install drainage-type, trap-seal primer valves 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.

K. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

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

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Reduced-pressure-principle backflow preventers.
5. Dual-check-valve backflow preventers.
7. Calibrated balancing valves.
8. Primary, thermostatic, water mixing valves.
9. Primary water tempering valves.
10. Outlet boxes.

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

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each backflow preventer according to authorities having jurisdiction and the device's reference standard.

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

3.5 ADJUSTING

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

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

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

END OF SECTION 221119
SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic cold- and hot-water circulation:


1.3 SEISMIC REQUIREMENTS

A. Component Importance Factor. All plumbing components shall be assigned a component importance factor. The component importance factor, $I_p$, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake.
2. The component contains hazardous materials.
3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

B. All other components shall be assigned a component importance factor, $I_p$, equal to 1.0.

C. Seismic Performance: Plumbing equipment, hangers and supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 and with the requirements specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment.

1. For components with a seismic importance factor of 1.0 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."

2. For components with a seismic importance factor of 1.5 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.
C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Protect bearings and couplings against damage.

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

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers:

1. Armstrong.
2. Aurora Pump; Pentair Pump Group (The).
3. Bell & Gossett Domestic Pump; ITT Industries.
4. Grundfos Pumps Corp.
5. Taco, Inc.
6. Thrush Company, Inc.
B. Description: Factory-assembled and -tested, overhung-impeller, single-stage, separately coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.

1. Pump Construction: All bronze.
   a. Casing: Radially split, cast iron, with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
   c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
   d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Bearings: Oil-lubricated; bronze-journal or ball type.

2. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently mounted to pump casing. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.3 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Anamet, Inc.
   2. Flex-Hose Co., Inc.
   3. Flexcraft Industries.
   4. Flex-Pression, Ltd.
   5. Flex-Weld, Inc.
   6. Fugate
   7. Hyspan Precision Products, Inc.
   9. Metraflex, Inc.
   10. Proco Products, Inc.
   11. Tozen America Corporation.
   12. Twin City Hose.
   13. Unaflex Inc.

B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include 125-psig minimum working-pressure rating and ends matching pump connections.

2.4 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
   1. On-off status of each pump.
   2. Alarm status.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION
A. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
B. Comply with HI 1.4.
C. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
D. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
E. Install separately coupled, horizontally mounted, in-line centrifugal pumps with motor and pump shafts horizontal.
F. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

3.3 CONNECTIONS
A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to pumps to allow service and maintenance.
C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
   1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
      a. Separately coupled, horizontally mounted, in-line centrifugal pumps.
   2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
   3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping.
discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Interlock pump with water heater burner and time delay relay.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Open discharge valve slowly.
8. Adjust temperature settings on thermostats.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 221123
SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

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

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

1.6 QUALITY ASSURANCE
A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent
piping; "NSF-sewer" for plastic sewer piping; "NSF-drain" for plastic drain piping, and "NSF-
tubular" for plastic continuous waste piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: All cast-iron waste, vent and sewer pipe and fittings shall conform to the requirements of CISPI Standard 301 and ASTM A 888. All products shall be marked with the collective trademark of the Cast Soil Pipe Institute and shall be listed by NSF International or receive prior approval of the engineer. All cast-iron pipe and fittings shall be American made and tested. Non-compliant import cast-iron products will not be permitted. Any non-compliant cast-iron product installed by the contractor on this project will be replaced at the contractor's expense and shall include all repairs, patching, painting and other incidental work required to return the project to its pre-remediation state.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AB&I Foundry
   b. Charotte Pipe
   c. Tyler Pipe

B. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO.
   b. Ideal
   c. Mission Rubber Company; a division of MCP Industries, Inc.
   d. Tyler Pipe.

3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. Listing: Couplings shall be listed by NSF International. Each coupling shall be embossed with the NSF seal.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Husky SD 4000.
   b. Clamp-All Corp HI-TORQ 125.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

### 2.3 DUCTILE-IRON PIPE AND FITTINGS

**A. Ductile-Iron, Mechanical-Joint Piping:**

1. **Ductile-Iron Pipe:** AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. **Ductile-Iron Fittings:** AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. **Glands, Gaskets, and Bolts:** AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

**B. Ductile-Iron, Grooved-Joint Piping:**

1. **Ductile-Iron Pipe:** AWWA C151/A21.51 with round-cut-grooved ends according to AWWA C606.
2. **Ductile-Iron-Pipe Appurtenances:**
   a. **Manufacturers:** Subject to compliance with requirements, [provide products by one of the following:]
      1) Anvil International.
      2) Shurjoint Piping Products.
      3) Victaulic Company.
   b. **Grooved-End, Ductile-Iron Fittings:** ASTM A 536 ductile-iron castings with dimensions matching AWWA C110/A 21.10 ductile-iron pipe or AWWA C153/A 21.53 ductile-iron fittings and complying with AWWA C606 for grooved ends.
   c. **Grooved Mechanical Couplings for Ductile-Iron Pipe:** ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.

### 2.4 PVC PIPE AND FITTINGS

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

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

**C. Adhesive Primer:** ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

**D. Solvent Cement:** ASTM D 2564.
1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EARTH MOVING
A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31 Section “Earth Moving.”

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices specified in Division 22 Section “Vibration and Seismic Controls for Plumbing Piping and Equipment.”

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

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

M. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: **2 percent downward in direction of flow for piping for NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.**
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
4. **Grease Waste: 2 percent downward in direction of flow for piping.**

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

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

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

P. Install engineered soil and waste drainage and vent piping systems as follows:


Q. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."
2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
3. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

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

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

### 3.3 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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

C. 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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves:

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

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

3.5 HANGER AND SUPPORT INSTALLATION

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

B. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.
C. Support horizontal piping and tubing within 12 inches of each fitting and coupling or valve and coupling.

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

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

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

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

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

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
6. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

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

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

F. Make fixture and equipment 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.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

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

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

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

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

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

3.9 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.

3.10 PIPING SCHEDULE
A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
B. Aboveground, soil and waste piping NPS 3 and smaller shall be the following:
   1. Hubless, cast-iron soil pipe and fittings CISPI hubless-piping couplings; and coupled joints.
C. Aboveground, soil and waste piping NPS 4 and larger shall be the following:
   1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.
D. Aboveground, vent piping NPS 3 and smaller shall be the following:
   1. Hubless, cast-iron soil pipe and fittings CISPI hubless-piping couplings; and coupled joints.
E. Aboveground, vent piping NPS 4 and larger shall be the following:
   1. Hubless, cast-iron soil pipe and fittings CISPI hubless-piping couplings; and coupled joints.
F. Underground, soil, waste, and vent piping NPS 3 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings CISPI hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

G. Underground, soil and waste piping NPS 4 and larger shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

H. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be the following:

1. Galvanized-steel pipe, pressure fittings, and threaded joints.

I. Mechanical Rooms & Kitchen Underground soil, waste, and vent piping any size shall be the following:

1. NPS 3 and smaller: Hubless, cast-iron soil pipe and fittings CISPI hubless-piping couplings; and coupled joints.
2. NPS 4 and larger: Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.

END OF SECTION 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Channel drainage systems.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   7. Flashing materials.

B. Related Sections include the following:
   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 SEISMIC REQUIREMENTS

A. Component Importance Factor. All plumbing components shall be assigned a component importance factor. The component importance factor, Ip, shall be taken as 1.5 if any of the following conditions apply:
   1. The component is required to function for life-safety purposes after an earthquake.
   2. The component contains hazardous materials.
   3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

B. All other components shall be assigned a component importance factor, Ip, equal to 1.0.

C. Seismic Performance: Plumbing equipment, hangers and supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 and with the requirements specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment.

1.4 DEFINITIONS

A. FOG: Fats, oils, and greases.
B. FRP: Fiberglass-reinforced plastic.
C. HDPE: High-density polyethylene plastic.
D. PE: Polyethylene plastic.
E. PP: Polypropylene plastic.
F. PVC: Polyvinyl chloride plastic.

1.5 SUBMITTALS
A. Field quality-control test reports.
B. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS
A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.
g. Sun Drainage Products

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Oatey.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Light Commercial Operation.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.
   h. Sun Drainage Products

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
15. Size: Same as connected branch.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
g. Sun Drainage Products

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: See Schedule at end of this Section:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Sun Drainage Products

5. Seepage Flange: Required.
6. Anchor Flange: Not required.
7. Outlet: Bottom.
8. Trap Material: Cast iron.
10. Trap Features: Trap-seal primer valve drain connection.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

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

4. Size: Same as connected soil, waste, or vent stack.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
7. Special Coating: Corrosion resistant on interior of fittings.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. 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.

B. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. 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.

D. 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.

E. 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.

F. Vent Cap Filters:
   1. Description: Activated carbon filter in housing for installation at vent terminal as manufactured by Sweet Filter.
   2. Size: Same as connected stack vent or vent stack.
2.5 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L5121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.


C. Fasteners: Metal compatible with material and substrate being fastened.

D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.6 MOTORS

A. General requirements for motors are specified in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

G. Assemble plastic channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

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

I. 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.

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

K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

L. Install vent cap filters on each vent pipe passing through roof.

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

N. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

O. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319
SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
B. Related Sections include the following:
   1. Division 22 Section "Sump Pumps."

1.3 DEFINITIONS
A. LLDPE: Linear, low-density polyethylene plastic.
B. PE: Polyethylene plastic.
C. PVC: Polyvinyl chloride plastic.
D. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.

1.5 SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
B. Shop Drawings:
C. Field quality-control inspection and test reports.
D. Delegated-Design Submittal:
1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

1.6 QUALITY ASSURANCE

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


PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301. All waste, vent, sewer and storm lines shall be soil pipe and fittings that conform to the requirements of CISPI Standard 301, ASTM A ** and shall be marked with the collective trademark of the Cast Soil Pipe Institute or Receive Prior approval of the engineer and manufactured by AB&l Foundry, Tyler Pipe, or Charlotte Pipe. In addition all Cast iron shall be American made and tested, no “non compliant” import cast iron will be permitted.

A. CISPI, Hubless-Piping Couplings:

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

      a. ANACO.
      b. Ideal
      c. Mission Rubber Company; a division of MCP Industries, Inc.
      d. Tyler Pipe.

3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

4. Listing: Couplings shall be listed by NSF International. Each coupling shall be embossed with the NSF seal.

B. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Clamp-All Corp HI-TORQ 80.
   c. Ideal HD
   d. Mission HW.
   e. Tyler Pipe Widebody.


3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 PVC PIPE AND FITTINGS

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

2.5 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
   b. Fernco, Inc.
   c. Logan Clay Products Company (The).
   d. Mission Rubber Co.
   e. NDS, Inc.
   f. Plastic Oddities, Inc.

2. Sleeve Materials:
   b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
PART 3 - EXECUTION

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

3.2 PIPING APPLICATIONS
A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
B. Aboveground storm drainage piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
C. Underground storm drainage piping shall be the following (to 6" above finished floor):
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.3 PIPING INSTALLATION
A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping."
B. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
C. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
D. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."
E. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Fire Plumbing."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
H. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of
standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

J. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.

K. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

L. Install underground PVC storm drainage piping according to ASTM D 2321.

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

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results Plumbing."


C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer than 100 Feet, if indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.
C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

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

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

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 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.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

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

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

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. 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.

3.8 CLEANING

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

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

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

END OF SECTION 221413
SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following storm drainage piping specialties:
   1. Cleanouts.
   2. Roof drains.
   3. Miscellaneous storm drainage piping specialties.
   4. Flashing materials.
B. Related Sections include the following:
   1. Division 22 Section "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer, air admittance valves, FOG disposal systems, grease interceptors and removal devices, oil interceptors, and solid interceptors.

1.3 DEFINITIONS
A. PUR: Polyurethane plastic.
B. PVC: Polyvinyl chloride plastic.

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

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

1.6 COORDINATION
A. Coordinate size and location of roof penetrations.
PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Sioux Chief Manufacturing Company, Inc
      e. Tyler Pipe; Wade Div.
      f. Watts Drainage Products Inc.
      g. Zurn Plumbing Products Group; Specification Drainage Operation.
      h. Sun Drainage Products

   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Oatey.
      c. Sioux Chief Manufacturing Company, Inc.
      e. Tyler Pipe; Wade Div.
      f. Watts Drainage Products Inc.
      g. Zurn Plumbing Products Group; Light Commercial Operation.
      h. Zurn Plumbing Products Group; Specification Drainage Operation.
      i. Sun Drainage Products

   2. Standard: ASME A112.36.2M for adjustable housing cleanout.
   3. Size: Same as connected branch.
   4. Type: Adjustable housing.
   5. Body or Ferrule: Cast iron.
   8. Closure: Brass plug with tapered threads.
   9. Adjustable Housing Material: Cast iron with threads.
   11. Frame and Cover Shape: Round.
   12. Top Loading Classification: Heavy Duty.
   13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
15. Size: Same as connected branch.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.
   h. Sun Drainage Products

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 ROOF DRAINS

A. Metal Roof Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: See Schedule at end of this section for drain descriptions:
   b. MIFAB, Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.
   h. Sun Drainage Products

3. Standard: ASME A112.21.2M.
5. Combination Flashing Ring and Gravel Stop: Required.
7. Extension Collars: Required.
8. Underdeck Clamp Required.

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

2.3 FLASHING MATERIALS

B. Fasteners: Metal compatible with material and substrate being fastened.
C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
D. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.
C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.
F. Install manufactured downspout boots at grade with top 18 inches above grade. Secure to building wall.
G. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
H. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

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

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423
SECTION 221429 – SUMP PUMP BASIN PACKAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following sump pumps and accessories, inside the building, for building sump drainage systems:

1. Sump pumps.
2. Sump basins.

B. Provide check and isolation valves.

1.3 SEISMIC REQUIREMENTS

A. Component Importance Factor. All plumbing components shall be assigned a component importance factor. The component importance factor, I_p, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake.
2. The component contains hazardous materials.
3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

B. All other components shall be assigned a component importance factor, I_p, equal to 1.0.

C. Seismic Performance: Plumbing equipment, hangers and supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 and with the requirements specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. For components with a seismic importance factor of 1.0 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."
2. For components with a seismic importance factor of 1.5 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type and size of sump specified. Include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.
B. Manufacturer Seismic Qualification Certification: Submit certification that systems, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Operation and Maintenance Data: For each sump pump to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sump pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Protect bearings and couplings against damage.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: By one of the following:

2.2 SUBMERSIBLE SUMP PUMPS

A. Manufacturers:

1. Bell and Gossett
2. Goulds Pumps; ITT Industries.
3. Grundfos Pumps Corp.
4. Hydromatic.

B. Description: Factory-assembled and -tested, duplex, sump high capacity, efficient, submersible, pumps complying with UL 778 and HI 1.1-1.2 and HI 1.3 for submersible sump pumps.

C. Casing: Cast Iron; with legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange suitable for piping connection.

D. Impeller: Stainless steel or other corrosion-resistant material.

E. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings and double-mechanical seals.

F. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection; three-conductor waterproof power cable of length required, and with grounding plug and cable-sealing assembly for connection at pump. Comply with requirements in Division 22 Section "Motors."

1. Moisture-Sensing Probe: Internal moisture sensor with moisture alarm.

G. Pump Discharge Piping: Factory or field fabricated, ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe.

H. Basin Cover: Steel plate.

I. Controls: See schedule.

2.3 SUMP PUMP BASINS

A. Description: Factory fabricated basin with sump, pipe connections, and separate cover.

B. Sump: Fabricate watertight, with sidewall openings for pipe connections.

1. Material: Polyethylene or fiberglass.
2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
3. Anchor Flange: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

C. Cover: Fabricate with openings having gaskets, seals, and bushings, for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Material: Steel.

2.4 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Anamet, Inc.
2. Flex-Hose Co., Inc.
3. Flexicraft Industries.
4. Flex-Pression, Ltd.
5. Flex-Weld, Inc.
6. Hyspan Precision Products, Inc.
8. Metraflex, Inc.
9. Proco Products, Inc.
10. Tozen America Corporation.
11. Unaflex Inc.

B. Description: 125-psig minimum working-pressure rating and ends matching pump connection:

1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to tubing.
2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.5 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

1. On-off status of each pump.
2. Alarm status.
3. High Water Alarm.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 SUMP INSTALLATION

A. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

C. Install sump pumps according to applicable requirements in HI 1.4.

D. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

E. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

F. Support piping so weight of piping is not supported by pumps.

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

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

C. Connect storm drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping.
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "Valves" for general-duty valves for drainage piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.
   1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
   2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

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

END OF SECTION 221429
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SECTION 223100 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes commercial water softeners.
   1. Chemicals.
   2. Water testing kits.

1.3 SEISMIC REQUIREMENTS

A. Component Importance Factor. All plumbing components shall be assigned a component importance factor. The component importance factor, \( I_p \), shall be taken as 1.5 if any of the following conditions apply:
   1. The component is required to function for life-safety purposes after an earthquake.
   2. The component contains hazardous materials.
   3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

B. All other components shall be assigned a component importance factor, \( I_p \), equal to 1.0.

C. Seismic Performance: Plumbing equipment, hangers and supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 and with the requirements specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment.
   1. For components with a seismic importance factor of 1.0 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."
   2. For components with a seismic importance factor of 1.5 the term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

1.4 DEFINITIONS


B. FRP: Fiberglass-reinforced plastic.

C. PE: Polyethylene plastic.
D. PVC: Polyvinyl chloride plastic.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Water Softeners. Include rated capacities, operating characteristics, furnished specialties, and accessories.
   2. Water testing kits.

B. Shop Drawings: For water softeners. Include plans, elevations, sections, details, and connections to piping systems.

A. Manufacturer Seismic Qualification Certification: Submit certification that plumbing equipment and components will withstand seismic forces defined in Division 22 Section "Mechanical Vibration and Seismic Controls." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Manufacturer Certificates: Signed by manufacturers certifying that water softeners comply with requirements.

C. Source quality-control test reports.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

G. Maintenance service agreement.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water softeners and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, where indicated.
D. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.

1.7 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softener that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures of mineral and brine tanks.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   d. Attrition loss of resin exceeding 3 percent per year.
   e. Mineral washed out of system during service run or backwashing period.
   f. Effluent turbidity greater and color darker than incoming water.
   g. Fouling of underdrain system, gravel, and resin, with turbidity or by dirt, rust, or scale from softener equipment or soft water, while operating according to manufacturer's written operating instructions.

2. Commercial Water Softener, Warranty Period: From date of Substantial Completion.
   a. Mineral Tanks: 10 years.
   b. Brine Tanks: Five years.
   c. Controls: 10 years.
   d. Underdrain Systems: Five years.

1.9 MAINTENANCE SERVICE
A. Maintenance: Submit four copies of manufacturer's "Agreement for Continued Service and Maintenance," before Substantial Completion, for Owner's acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing to include replacing materials and equipment. Include one-year term of agreement with option for one-year renewal.

PART 2 - PRODUCTS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2.2 COMMERCIAL WATER SOFTENERS

A. Description: Factory-assembled, pressure-type water softener.

1. Manufacturers:
   b. Kinetico Incorporated.
   c. Marlo, Inc.
   d. Water & Power Technologies, Inc.
   e. Northstar
   f. CSI Water Treatment Systems, Inc.
   g. ECI
   h. Pacific

2. Comply with NSF 61, "Drinking Water System Components--Health Effects."

3. Configuration: Twin unit with two mineral tanks and one brine tank, factory mounted on skid.

4. Mineral Tanks: Steel, electric welded; pressure-vessel quality.
   a. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
   b. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels."
   c. Pressure Rating: 125 psig > minimum.
   d. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F.
   e. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
   f. Handholes: 4 inches round or 4 by 6 inches elliptical, in top head and lower sidewall of tanks 30 inches and smaller in diameter.
   g. Manhole: 11 by 15 inches in top head of tanks larger than 30 inches in diameter.
   h. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
   i. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication unless tank is stainless steel.
   j. Finish: Exterior of tank spray painted with rust-resistant prime coat, 2- to 3-mil dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil dry film thickness.
   k. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
   l. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even flow distribution through resin bed.
   m. Liner: PE, ABS, or other material suitable for potable water.

5. Controls: Fully automatic; factory mounted on unit and factory wired.
   a. Adjustable duration of various regeneration steps.
   b. Push-button start and complete manual operation.
   c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
d. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.

e. Pointer on pilot-control valve shall indicate cycle of operation.

f. Means of manual operation of pilot-control valve if power fails.

g. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

1) Slow opening and closing, nonslam operation.
2) Diaphragm guiding on full perimeter from fully open to fully closed.
3) Isolated dissimilar metals within valve.
4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
5) Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
6) Sampling cocks for soft water.
7) Special tools are not required for service.

h. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.

1) Meter Control: Equip each mineral tank with signal-register-head water meter that will produce electrical signal indicating need for regeneration on reaching hand-set total in gallons. Design so signal will continue until reset.
2) Demand-Initiated Control: Equip single mineral-tank units with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons. Design so head automatically resets to preset total in gallons for next service run.
3) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to initiate regeneration at preset total in gallons. Design so heads automatically reset to preset total in gallons for next service run. Include electrical lockout to prevent simultaneous regeneration of both tanks.
4) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tank. Set to repeat with other tank. Include electrical lockout to prevent simultaneous regeneration of both tanks.
5) Demand-Initiated Control: Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to automatically regenerate at preset total in gallons. Design so heads automatically reset to preset total in gallons for next service run. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.
6) Demand-Initiated Control: Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tanks. Set to repeat with other tanks. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.

6. Brine Tank: Combination measuring and wet-salt storing system.

a. Tank and Cover Material: Fiberglass, 3/16 inch thick; or molded PE, 3/8 inch thick.
b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
c. Size: Large enough for at least four regenerations at full salting.

7. Factory-Installed Accessories:
   a. Piping, valves, tubing, and drains.
   b. Sampling cocks.
   c. Main-operating-valve position indicators.
   d. Water meters.

2.3 WATER TESTING SETS
A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.4 SOURCE QUALITY CONTROL
A. Hydrotastically test mineral tanks before shipment to minimum of one and one-half times pressure rating.
B. Prepare test reports.

PART 3 - EXECUTION

3.1 CONCRETE BASES
A. Install concrete bases of dimensions indicated for commercial water softeners. Refer to Division 22 Section "Common Work Results for Plumbing."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevation required for proper attachment to supported equipment.
B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.2 WATER SOFTENER INSTALLATION
A. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
B. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
C. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.3 CONNECTIONS

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

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

C. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

D. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
   1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
   2. Plastic valves are specified in Division 22 Section "Domestic Water Piping."
   3. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

E. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping."
   1. Exception: Water softeners with factory-installed pressure gages at locations indicated.
   2. Exception: Water softeners in hot-water service.

F. Install valved bypass water piping around water softeners.
   1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
   2. Water piping is specified in Division 22 Section "Domestic Water Piping."
   3. Exception: Household water softeners.
   4. Exception: Water softeners in hot-water service.

G. Install drains as indirect wastes to spill into open drains or over floor drains.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

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

1. 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 unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

3.5 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. Add water to brine tanks and fill with salt.


C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:

2. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
4. ASTM D 1126, "Test Method for Hardness in Water."
5. ASTM D 1129, "Terminology Relating to Water."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water softeners. Refer to Division 01 "Demonstration and Training" Section

END OF SECTION 223100
SECTION 223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 GENERAL

A. Submit product data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories and indicating dimensions, required clearances, methods of component assembly, and piping and wiring connections.

B. Submit wiring diagrams from manufacturers detailing electrical requirements for electrical power supply wiring to water heaters. Include ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls. Differentiate between portions of wiring that are factory installed and portions that are to be field installed.

C. UL Standards: Provide water heaters complying with the following:
   1. UL 174, "Household Electric Storage Tank Water Heaters."
   2. UL 1453, "Electric Booster and Commercial Storage Tank Water Heaters."

D. Electrical Component Standard: Provide components complying with NFPA 70 "National Electrical Code."

E. Listing and Labeling: Provide water heaters that are listed and labeled.
   1. The Terms "Listed" And "Labeled": As defined in the National Electrical Code, Article 100.

F. AGA Standards: Provide water heaters that bear the label of the American Gas Association.

G. AGA Standards: Provide pressure and temperature relief valves that bear the label of the American Gas Association and relieve the entire input of the water heater.

H. ASHRAE Standards: Provide water heaters with performance efficiencies not less than prescribed in ASHRAE 90.1, "Energy Conservation in New Building Design."

1.2 PRODUCTS

A. Manufacturers:

   1. Sealed Combustion High Efficiency Tank Type Gas-Fired Water Heaters:
      a. A.O. Smith Water Products Co. Div.; A.O. Smith Corp.
      b. Bradford White
      c. State Water Heaters

      1. Fuel: Natural gas.
      2. Insulation: Fiberglass, surrounding tank.
4. Tank: Glass-lined steel, with anode rods and drain valve.
5. Controls: Adjustable thermostat.
7. Temperature and Pressure Relief Valve: AGA rated and labeled.

C. Provide concrete bases as indicated.
   1. Concrete: Portland cement; mix to a 4000-psi, 28-day compressive strength.
      a. Cement: ASTM C 150, Type I.
      b. Fine Aggregate: ASTM C 33, sand.
   3. Reinforcement Bars: ASTM A 615, Grade 60, deformed.

D. Earthquake Bracing Assemblies: Commercial concrete floor mounted steel angle bracing with steel water heater straps.

E. Steel, Precharged Water Storage Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Covert Pump Div.; Covert Manufacturing, Inc.
   d. Expanflex, Inc.
   e. GSW Water Products Co.
   f. A.O. Smith; Aqua-Air Div. (Available from Goulds Pumps, Inc.)
   g. State Industries, Inc.
   h. John Wood Co.

   1. Watts General: Provide precharged, vertical, steel water storage tanks of sizes and capacities as indicated.
   4. Construction: ASME Code, steel, constructed with welded joints, for 125 psig working pressure, and factory-precharged to minimum system operating pressure at tank, as indicated.
   5. Interior Lining: Epoxy of thickness that meets requirements of applicable AWWA or FDA and EPA regulatory standards for tasteless and odorless, potable water tank linings.
   6. Interior Lining: Polypropylene of thickness that meets requirements of applicable AWWA or FDA and EPA regulatory standards for tasteless and odorless, potable water tank linings.
   7. Tappings: Provide tappings of sizes and in locations as indicated. Provide 1 tapping to serve as both inlet and outlet connection.
      a. Tappings 2 Inches and Smaller: Factory-fabricated, threaded, female, welded before testing and labeling.
      b. Tappings 2-1/2 Inches and Larger: Factory-fabricated, flanged, welded before testing and labeling.
8. Accessories: Provide air-charging and pressure relief valves and pressure gages as indicated.

1.3 EXECUTION

A. Form concrete equipment bases using framing lumber with form release compounds. Chamfer top edges and corners.
   1. Install reinforcing bars, and place anchor bolts and sleeves using manufacturer's installation template.
   2. Place concrete and allow to cure before installation of equipment.

B. Install water heaters level and plumb on bases in accordance with manufacturer's written installation instructions. Firmly anchor units in locations indicated, and maintain manufacturer's recommended clearances. Orient so controls and devices needing servicing are accessible.

C. Install thermometers on water heater inlet and outlet piping.


E. Piping Installation Requirements: The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
   1. Install piping adjacent to equipment arranged to allow servicing and maintenance.
   2. Connect hot and cold water piping to units with shutoff valves and unions. Connect hot water circulating piping to unit with shutoff valve, check valve, and union. Extend relief valve discharge to closest floor drain.
      a. Where water heater piping connections are dissimilar metals, make connections with dielectric fittings. specified in Division 15 Section "Basic Piping Materials and Methods."
      b. Install vacuum relief valve in cold water inlet piping.
   3. Connect gas supply piping to burner with drip leg, tee, gas cock, and union; minimum size same as inlet connection. Arrange piping to allow unit servicing.
      a. Install vent piping from gas train pressure regulators and valves to outside the building. Terminate vent piping with brass screened vent cap fitting. Do not combine vents except with approval of local authority.
      b. Install gas pressure regulators where indicated.
   4. Install drain as indirect waste to spill into open drain or over floor drain.
      a. Install drain valve at low point in water piping, for water heaters not having tank drain.
   5. Electrical Connections: Power wiring and disconnect switches are specified in electrical Work.
      a. Grounding: Connect unit components to ground in accordance with the National Electrical Code.
   7. Earthquake Bracing Assemblies: Install earthquake bracing secure to structural members per the manufacturer's installation requirements.

F. Field Quality Control: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide start-up service, and demonstrate and train Owner's maintenance personnel as specified below.
   1. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.
2. Perform the following before start-up final checks:
   a. Fill water heaters with water.
   b. Check piping systems test complete.
   c. Check for piping connections leaks.
   d. Check for clear vent.
   e. Test operation of safety controls and devices.

3. Perform the following start-up procedures:
   a. Energize circuits.
   b. Adjust operating controls.
   c. Adjust hot water outlet temperature setting.

END OF SECTION 223400
SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Faucets for lavatories and sinks.
   2. Flushometers.
   3. Toilet seats.
   4. Protective shielding guards.
   5. Fixture supports.
   7. Urinals.
   8. Lavatories.
  11. Service sinks.

B. Related Sections include the following:
   1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
   2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
   3. Division 22 Section "Emergency Plumbing Fixtures."
   4. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

C. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

D. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

E. FRP: Fiberglass-reinforced plastic.

F. PMMA: Polymethyl methacrylate (acrylic) plastic.
G. PVC: Polyvinyl chloride plastic.


1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

  1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

  1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
  2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
  6. Vitreous-China Fixtures: ASME A112.19.2M.
8. Whirlpool Bathtub Fittings: ASME A112.19.8M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
5. Hose-Connection Vacuum Breakers: ASSE 1011.

I. Comply with the following applicable standards and other requirements specified for bathtub/shower and shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

2. Brass and Copper Supplies: ASME A112.18.1.

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

1. Disposers: ASSE 1008 and UL 430.
4. Floor Drains: ASME A112.6.3.
5. Grab Bars: ASTM F 446.
7. Off-Floor Fixture Supports: ASME A112.6.1M.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

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

   a. Chicago Faucets.
   b. T & S Brass and Bronze Works, Inc.
   c. Moen, Inc.

2.2 BATHTUB/SHOWER FAUCETS

A. Bathtub/Shower Faucets:

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

   a. Chicago Faucets.
   b. Leonard Valve Company.
   c. Moen, Inc.
   d. Powers; a Watts Industries Co.
   e. Symmons Industries, Inc.
   f. T & S Brass and Bronze Works, Inc.
2.3 SHOWER FAUCETS

A. Shower Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Chicago Faucets.
   b. Leonard Valve Company.
   c. Moen, Inc.
   d. Powers; a Watts Industries Co.
   e. Symmons Industries, Inc.
   f. T & S Brass and Bronze Works, Inc.

2.4 SINK FAUCETS

A. Sink Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Chicago Faucets.
   b. T & S Brass and Bronze Works, Inc.
   c. Moen, Inc.

2.5 FLUSHOMETERS

A. Flushometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sloan Valve Company.
   b. Zurn Plumbing Products Group; Commercial Brass Operation.
   c. Moen, Inc.
   d. Advanced Modern Technologies Corporation

2.6 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Centoco Manufacturing Corp.
   c. Church Seats.
   d. Olsonite Corp.
   e. Sperzel.

2. Description: Toilet seat for water-closet-type fixture.
a. Material: Molded, solid plastic with antimicrobial agent.
b. Configuration: Open front without cover.
c. Size: Elongated.
d. Hinge Type: CK, check.
e. Class: Heavy-duty commercial.

2.7 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Engineered Brass Co.
      b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
      c. McGuire Manufacturing Co., Inc.
      d. Plumberex Specialty Products Inc.
      e. TCI Products.
      f. TRUEBRO, Inc.
      g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

2. Protective Shielding Piping Enclosures:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. TRUEBRO, Inc.

   2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements. Product shall also meet the ASTM E 84 25/450 smoke and flame rating.

2.8 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
7. Sun Drainage Products

B. Urinal Supports:
1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

C. Lavatory Supports:
1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2.9 WATER CLOSETS
A. Water Closets:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Eljer.
   d. Kohler Co.
   e. Advanced Modern Technologies Corporation

2.10 URINALS
A. Urinals:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Inc.
   b. Briggs Plumbing Products, Inc.
   c. Crane Plumbing, L.L.C./Fiat Products.
   d. Eljer.
   e. Kohler Co.
   f. Advanced Modern Technologies Corporation

2.11 LAVATORIES
A. Lavatories:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Inc.
   b. Briggs Plumbing Products, Inc.
   c. Crane Plumbing, L.L.C./Fiat Products.
   d. Eljer.
   e. Kohler Co.
2.12 COMMERCIAL SINKS
A. Commercial Sinks:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elkay Manufacturing Co.
      b. Just Manufacturing Company.

2.13 SHAMPOO BOWLS
A. Shampoo Bowls:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Belvedere USA Corporation; a Subsidiary of the Wella Corporation, North America.

2.14 BATHTUBS
A. Bathtubs
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Inc.
      b. Briggs Plumbing Products, Inc.
      c. Crane Plumbing, L.L.C./Fiat Products.
      d. Eljer.
      e. Kohler Co.

2.15 SERVICE SINKS
A. Service Sinks:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Inc.
      b. Commercial Enameling Company.
      c. Eljer.
      d. Kohler Co.
      e. Crane Plumbing, L.L.C./Fiat Products.

2.16 KITCHEN EQUIPMENT
A. Kitchen Equipment (as noted on Kitchen Equipment Schedule):
1. Rough-in and connect to Kitchen equipment as per the Kitchen Equipment Rough-in drawings. Provide all "P" traps required, chrome-plated cast brass. Tail pieces and trap arms shall be chrome-plated 17 ga. brass tubing.
2. Provide Precision Plumbing Products water hammer arrestors upstream of all quick-closing valves, such as on disposers and dishwasher.
3. Gas and water services to portable and countertop appliances shall be connected to equipment with flexible tubing and quick-disconnect fittings. Gas fittings and hoses shall be A.G.A. approved for commercial kitchen equipment.
4. All exposed piping and fittings shall be chrome-plated or stainless steel. Furnish and install stops on all hot and cold water lines at equipment.
5. Provide shut-off valves and unions in all gas, steam and condensate lines at each connection to equipment.
6. All piping penetrations through walls shall be a minimum of 6" above the floor.
7. Provide 3/4" Watts model U5BLP pressure reducing valve on supply line to dishwasher.
8. Provide check valves on supplies to hose sprays.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install counter-mounting fixtures in and attached to casework.

G. Install fixtures level and plumb according to roughing-in drawings.
H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

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

J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

K. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

L. Install toilet seats on water closets.

M. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

N. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

O. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install shower flow-control fittings with specified maximum flow rates in shower arms.

Q. Install traps on fixture outlets.

   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

R. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

S. Set bathtubs and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

T. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

U. All plumbing fixtures are to be mounted at the height specified on the Architectural drawings.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.
B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

3.8 KITCHEN EQUIPMENT

K-4.1 Through K-42 (as noted on Kitchen Equipment Schedules):

Rough-in and connect to kitchen equipment and fixtures as indicated on the Kitchen Equipment Rough-in Drawings. Provide all "P" traps, tail pieces, indirect waste piping, stops, supplies and shut off valves required.

Provide chrome plated or stainless steel piping for all exposed piping.

Provide cast brass, chrome plated "P" traps and 17 gauge, chrome plated brass, trap arms and indirect waste lines.

Provide water hammer arrestors on supply line to all quick closing valves i.e. disposers, dishwashers, etc.

Provide direct acting pressure reducing valve on water supply to dishwasher, minimum ¾” size.

Provide shut off valves and unions on all gas supplies to fixed equipment.

Provide flexible tubing and quick disconnect fittings for all water and gas connections to portable equipment and sinks. Provide AGA gas fittings and hoses approved for commercial kitchen equipment.

Provide all piping penetrations through walls a minimum of 6” above the finished floor.

Provide Watts Series 7 dual check valve on hot and cold water supply lines to all sensor operated valves and faucets with hand held hoses or wands.

Provide Powers Series e480 thermostatic mixing valve with check valves on inlets at all hand washing sinks.

END OF SECTION 224000
PART 1 - GENERAL

1.1 GENERAL CONDITIONS

A. The General Conditions of the Contract, with the amendments, supplements, forms and requirements in Division 1, and herewith made a part of this Division.

B. All sections of Division 21, 22, & 23 shall comply with the Mechanical General Requirements. The standards established in this section as to quality of materials and equipment, the type and quality of workmanship, mode of operations, safety rules, code requirements, etc., shall apply to all sections of this Division as though they were repeated in each Division.

C. Mechanical equipment that is pre-purchased if any will be assigned to the Mechanical Contractor. By assignment to the Mechanical Contractor, the Mechanical Contractor shall accept and installed the equipment and provide all warrantees and guarantees as if the Mechanical Contractor had purchased the equipment.

D. Construction Indoor-Air Quality Management
   1. Comply with SMACNA’s “SMACNA IAQ Guideline for Occupied Buildings under Construction.”
      a. If Owner authorizes use of permanent heating, cooling, and ventilating systems during construction period as specified in Division 01 Section “Temporary Facilities and Controls,” install filter media having a MERV 8 according to ASHRAE 52.2 at each return-air inlet for the air-handling system used during construction.
      b. Replace all air filters immediately prior to occupancy.

1.2 SCOPE OF WORK

A. The project described herein is the Ellis Elementary School. This work shall include all labor, materials, equipment, fixtures, and devices for the entire mechanical work and a complete operating and tested installation as required for this project.

B. This Division will schedule the boiler inspection and pay for all costs associated with certifying the boiler with the state.

1.3 CODES & ORDINANCES

A. All work shall be executed in accordance with all underwriters, public utilities, local and state rules and regulations applicable to the trade affected. Should any change in the plans and Specifications be required to comply with these regulations, the Contractor shall notify the Architect before the time of submitting his bid. After entering into contract, the Contractor will be held to complete all work necessary to meet these requirements without extra expense to the Owner. Where work required by drawings or specifications is above the standard required, it shall be done as shown or specified.

B. Applicable codes:

1.4 INDUSTRY STANDARDS

A. All work shall comply with the following standards.
1. Associated Air Balance council (AABC)
2. Air Conditioning and Refrigeration Institute (ARI)
3. Air Diffusion council (ADC)
4. Air Movement and Control Association (AMCA)
5. American Gas Association (AGA)
6. American National Standards Institute (ANSI)
7. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
8. American Society of Mechanical Engineers (ASME)
10. American Water Works Association (AWWA)
11. Cooling Tower Institute (CTI)
12. ETL Testing Laboratories (ETL)
13. Institute of Electrical and Electronic Engineers (IEEE)
14. Hydronics Institute (HI)
15. Manufacturers Standardization Society of the Valve and Fitting Industry (MSS)
17. National Electrical Code (NEC)
18. National Electrical Manufacturers Association (NEMA)
19. National Electrical Safety code (NESC)
21. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA)
22. Underwriters Laboratories (UL)
23. Tubular Exchanger Manufacturers Association, Inc. (TEMA)
24. Heat Exchanger Institute (HEI)
25. Hydraulic Institute (HI)
26. Thermal Insulation Manufacturer’s Association (TIMA)
27. Scientific Apparatus Makers Association (SAMA)

B. Compliance Verification:
1. All items required by code or specified to conform to the ASME code shall be stamped with the ASME seal.
2. Form U-1, the manufacturer’s data report for pressure vessels, is to be included in the Operation and Maintenance Manuals. National Board Register (NBR) numbers shall be provided where required by code.
3. Manufactured equipment which is represented by a UL classification and/or listing, shall bear the UL or equivalent ETL label.

1.5 UTILITIES & FEES

A. All fees for permits required by this work will be paid by this division. The contractor shall obtain the necessary permits to perform this work. Unless noted otherwise, all systems furnished and or installed by this Contractor, shall be complete with all utilities, components, commodities and accessories required for a fully functioning system. This Contractor shall furnish smoke
generators when required for testing, furnish glycol for glycol piping systems, full load of salt to fill brine tank for water softening system, furnish cleaners and water treatment additives.

1.6 SUBMITTALS AND SHOP DRAWINGS

A. General: As soon as possible after the contract is awarded, but in no case more than 45 calendar days thereafter, the Contractor shall submit to the Architect manufacturer's data on products and materials to be used in the installation of mechanical systems for this project. The review of the submitted data will require a minimum of 14 days. The first day starts after the day they are received in the engineer's office to which the project is being constructed from. If the Contractors schedule requires return of submitted literature in less than the allotted time, the Contractor shall accelerate his submittal delivery date. The Contractor shall resubmit all items requiring re-review within 14 days of returned submittals. Refer to each specification section for items requiring submittal review. **If the re-submittal is returned a 2nd time for correction the Contractor will provide the specific equipment that is specified on the drawings and/or the specifications.** Written approval of the Owner's Representative shall be obtained before installing any such equipment or materials for the project.

B. Review by the Owner's Representative is for general conformance of the submitted equipment to the project specification. **In no way** does such review relieve this Contractor of his obligation to furnish equipment and materials that comply in detail to the specification **nor does it relieve** the Contractor of his obligation to determine actual field dimensions and conditions that may affect his work. Regardless of any items overlooked by the submittal review, the requirements of the contract drawings and specifications **must be followed** and are not waived or superseded in any way by the review.

C. By description, catalog number, and manufacturer's names, standards of quality have been established by the Architect and the Engineer for certain manufactured equipment items and specialties that are to be furnished by this Division. Alternate products and equipment may be proposed for use only if specifically named in the specifications or if given written prior approval in published addenda. Design equipment is the equipment listed on the drawings or if not listed on the drawings is the equipment first named in the specifications.

D. If the Engineer is required to do additional design work to incorporate changes caused by submitting equipment or products, different than the design equipment specified, as defined above, the contractor shall reimburse the engineer for additional time and expenses at the engineer's current, recognized, hourly rates.

E. Submittal Format: At the contractor's discretion, project submittals may be in either of the formats described in the following paragraphs, but mixing the two formats is not acceptable.

1. Hardcopy Submittal Format: Six (6) copies of the descriptive literature covering products and materials to be used in the installation of mechanical systems for this project will be provided for review. The submittals shall be prepared in an orderly manner, contained in a 3-ring loose-leaf binder with index and identification tab for each item or group of items and for each specification section. All items shall be submitted at one time except automatic temperature control drawings and seismic restraint drawings which may be submitted separately within 120 days of the contract award date. Partial submittals will not be reviewed until the complete submittal is received.
   a. Submitted literature shall bear the Contractor's stamp, indicating that he has checked all equipment being submitted; that each item will fit into the available space with the accesses shown on the drawings; and, further, that each item conforms to the capacity and quality standards given in the contract documents.
b. Submitted literature shall clearly indicate performance, quality, and utility requirements; shall show dimension and size of connection points; and shall include derating factors that were applied for each item of equipment to provide capacity at job site elevation. Temperature control submittals shall include piping and wiring diagrams, sequence of operation and equipment. Equipment must fit into the available space with allowance for operation, maintenance, etc. Factory piped and wired equipment shall include shop drawings for all internal wiring and piping furnished with the unit.

c. Submitted literature shall clearly show all required field install wiring, piping, and accessory installations required by the Contractor to provide a complete operating system.

2. Electronic Submittal Format: Identify and incorporate information in each electronic submittal file as follows:
   a. All items shall be submitted at one time except automatic temperature control drawings and seismic restraint drawings which may be submitted separately within 120 days of the contract award date. Partial submittals will not be reviewed until the complete submittal is received.
   b. Submitted electronic file shall bear the Contractor's stamp, indicating that he has checked all equipment being submitted; that each item will fit into the available space with the accesses shown on the drawings; and, further, that each item conforms to the capacity and quality standards given in the contract documents.
   c. Submitted electronic file shall clearly indicate performance, quality, and utility requirements; shall show dimension and size of connection points; and shall include derating factors that were applied for each item of equipment to provide capacity at job site elevation. Temperature control submittals shall include piping and wiring diagrams, sequence of operation and equipment. Equipment must fit into the available space with allowance for operation, maintenance, etc. Factory piped and wired equipment shall include shop drawings for all internal wiring and piping furnished with the unit.
   d. Submitted electronic file shall clearly show all required field install wiring, piping, and accessory installations required by the Contractor to provide a complete operating system.
   e. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
   f. Name file with submittal number or other unique identifier, including revision identifier.
   g. Electronic file shall be completely electronically searchable or it will be rejected.
   h. Provide means for insertion to permanently record Contractor’s review and approval markings and action taken by:
      1) Architect.
   i. Transmittal Form for Electronic Submittals:
      1) Use one of the following options acceptable to the Owner;
         a) Software-generated form from electronic project management software.
         b) Electronic form.
      2) The Electronic Submittal shall contain the following information:
         a) Project name.
         b) Date.
         c) Name and address of Architect.
d) Name of Construction Manager.
e) Name of Contractor.
f) Name of firm or entity that prepared submittal.
g) Names of subcontractor, manufacturer, and supplier.
h) Category and type of submittal.
i) Submittal purpose and description.
j) Specification Section number and title.
k) Specification paragraph number or drawing designation and generic name for each of multiple items.
l) Drawing number and detail references, as appropriate.
m) Location(s) where product is to be installed, as appropriate.
n) Related physical samples submitted directly.
o) Indication of full or partial submittal.
p) Transmittal number[, numbered consecutively].
q) Submittal and transmittal distribution record.
r) Other necessary identification.
s) Remarks.

j. Metadata: Include the following information as keywords in the electronic submittal file metadata:
   1) Project name.
   2) Number and title of appropriate Specification Section.
   3) Manufacturer name.
   4) Product name.

1.7 DRAWINGS AND MEASUREMENTS

A. Construction Drawings: The contract document drawings show the general design, arrangements, and extent of the system. In certain cases, the drawings may include details that show more nearly exact locations and arrangements; however, the locations, as shown diagrammatically, are to be regarded as general.

B. It shall be the work of this Section to make such slight alterations as may be necessary to make adjustable parts fit to fixed parts, leaving all complete and in proper shape when done. All dimensions given on the drawings shall be verified as related to this work and with the Architect’s office before work is started.

C. This Section shall carefully study building sections, space, clearances, etc., and then provide offsets in piping or ductwork as required to accommodate the building structure without additional cost to the Owner. In any case and at any time during the construction process, a change in location required by obstacles or the installation of other trades not shown on the mechanical plans shall be made without charge.

D. The drawings shall not be scaled for roughing in measurements nor shall they be used as shop drawings. Where drawings are required for these purposes or where drawings must be made from field measurements, the Contractor shall take the necessary measurements and prepare the drawings. Shop drawings of the various subcontractors shall be coordinated to eliminate all interferences and to provide sufficient space for the installation of all equipment, piping, ductwork, etc.

E. The drawings and specifications have been prepared to supplement each other and they shall be interpreted as an integral unit with items shown on one and not the other being furnished and installed as though shown and called out on both.
F. Coordination Drawings: The contractor shall provide coordination drawings for mechanical rooms, fan rooms, equipment rooms, and congested areas to eliminate conflicts with equipment, piping, or work of other trades. The drawings shall be a minimum scale of 1/4 inch = 1 foot and of such detail as may be required by the Engineer to fully illustrate the work. These drawings shall include all piping, conduit, valves, equipment, and ductwork.

G. Sheet-metal shop drawings will be required for all ductwork in the entire building. These drawings will show all ductwork in the entire building and shall be coordinated with architectural, structural and electrical portions of the project. The contractor shall specifically obtain copies of the structural shop drawings and shall coordinate the ductwork shop drawings with approved structural members. These drawings shall be submitted to the engineer for review prior to any fabrication. The contractor is responsible for all modifications necessary to accommodate duct installation within the structural, architectural and electrical restrictions. These drawings, once reviewed by the engineer, will be made available to all mechanical, electrical, and fire sprinkler subcontractors to coordinate installation of their work.

1.8 CONTRACTOR’S USE OF BUILDING EQUIPMENT

A. The Contractor may use equipment such as electric motors, fans, heat exchangers, filters, etc., with the written permission of the Owner. As each piece of equipment is used (such as electric motors and fans), maintenance procedures approved by the manufacturer are to be followed. A careful record is to be kept of the length of the time the equipment is used, maintenance procedures followed, and any difficulty encountered. The record is to be submitted to the Owner upon acceptance. All fan belts and filter media (such as bearings) shall be carefully inspected just prior to acceptance. Any excessive wear noted shall require replacement. New filter media shall be installed in air handlers at the time systems are turned over to the owner.

1.9 EXISTING CONDITIONS

A. The Contractor shall carefully examine all existing conditions that might affect the mechanical system and shall compare these conditions with all drawings and specifications for work included under this contract. He shall, at such time, ascertain and check all conditions that may affect his work. No allowance shall subsequently be made in his behalf for an extra expense incurred as a result of his failure or neglect to make such examination. This Contractor shall include in his bid proposal all necessary allowances to repair or replace any item that will remain or will be removed, and any item that will be damaged or destroyed by new construction.

B. The Contractor shall remove all abandoned piping, etc., required by new construction and cap or plug openings. No capping, etc., shall be exposed in occupied areas. All openings of items removed shall be sealed to match adjacent surfaces.

C. The Contractor shall verify the exact location of all existing services, utilities, piping, etc., and make connections to existing systems as required or as shown on the drawings. The exact location of each utility line, together with size and elevation, shall be established before any on-site lines are installed. Should elevation or size of existing main utility lines make connections to them impossible as shown on drawings, then notification of such shall immediately be given to the Owners Representative for a decision.
1.10 EQUIPMENT CAPACITIES

A. Capacities shown for equipment in the specifications and on the drawings are the minimum acceptable. No equipment shall be considered as an alternate that has capacities or performance less than that of design equipment.

B. All equipment shall give the specified capacity and performance at the job-site elevation. Manufacturers’ standard ratings shall be adjusted accordingly. All capacities and performances listed on drawings or in specifications are for job-site conditions.

1.11 SEISMIC REQUIREMENTS FOR EQUIPMENT

A. All equipment shall be furnished structurally adequate to withstand seismic forces as outlined in the International Building Code. Refer to section Mechanical Vibration Controls and Seismic Restraints. Equipment bases shall be designed for direct attachment of seismic snubbers and/or seismic anchors.

1.12 COOPERATION WITH OTHER TRADES

A. The Contractor shall refer to other drawings and parts of this specification that cover work of other trades that is carried on in conjunction with the mechanical work such that all work can proceed without interference resulting from lack of coordination.

B. The Contractor shall properly size and locate all openings, chases, sleeves, equipment bases, and accesses. He shall provide accurate wiring diagrams to the Electrical Contractor for all equipment furnished under this Division.

C. The ceiling cavity must be carefully reviewed and coordinated with all trades. In the event of conflict, the installation of the mechanical equipment and piping shall be in the following order: plumbing, waste, and soil lines; supply, return, and exhaust ductwork; water piping; medical gases; fire protection piping; and pneumatic control piping.

D. The mechanical Contractor shall insure that the installation of all piping, ducts and equipment is in compliance with Articles 110-16 and 384-4 of the National Electrical Code relative to proper clearances in front of and over all electrical panels and equipment. No piping or ductwork will be allowed to run over electrical panel.

1.13 RESPONSIBILITY OF CONTRACTOR

A. The Contractor is responsible for the installation of a satisfactory piece of work in accordance with the true intent of the drawings and specifications. He shall provide, as a part of his work and without expense, all incidental items required even though these items are not particularly specified or indicated. The installation shall be made so that its several component parts will function together as a workable system and shall be left with all equipment properly adjusted and in working order. The Contractor shall familiarize the Owner's Representative with maintenance and lubrication instructions as prepared by the Contractor and shall explain and fully instruct him relative to operating, servicing, and maintenance of them.

B. If a conflict arises between the drawings and the specifications the most stringent procedure/action shall be followed. A clarification to the engineer will help to determine the course of action to be taken. If a conflict arises between specification sections the engineer will determine which course of action is to be followed.
1.14 PIPE AND DUCT OPENINGS AND EQUIPMENT RECESSES

A. Pipe and duct chases, openings, and equipment recesses shall be provided by others only if shown on architectural or structural drawings. All openings for the mechanical work, except where plans and specifications indicate otherwise, shall be provided as work of this Division. Include openings information with coordination drawings.

B. Whether chases, recesses, and openings are provided as work of this Division or by others, this Contractor shall supervise their construction and be responsible for the correct size and location even though detailed and dimensioned on the drawings. This Contractor shall pay for all necessary cutting, repairing, and finishing if any are left out or incorrectly made. All necessary openings thru existing walls, ceilings, floors, roofs, etc. shall be provided by this Contractor unless indicated otherwise by the drawing and/or specifications.

1.15 UNFIT OR DAMAGED WORK

A. Any part of this installation that fails, is unfit, or becomes damaged during construction, shall be replaced or otherwise made good. The cost of such remedy shall be the responsibility of this Division.

1.16 WORKMANSHIP

A. Workmanship shall be the best quality of its kind for the respective industries, trades, crafts, and practices, and shall be acceptable in every respect to the Owner's representative. Nothing contained herein shall relieve the Contractor from making good and perfect work in all details in construction.

1.17 SAFETY REGULATION

A. The Contractor shall comply with all local, Federal, and OSHA safety requirements in performance with this work. (See General Conditions). This Contractor shall be required to provide equipment, supervision, construction, procedures, and all other necessary items to assure safety to life and property.

1.18 ELECTRICAL SERVICES

A. All equipment control wiring and all automatic temperature control wiring including all necessary contacts, relays, and interlocks, whether low or line voltage, except power wiring, shall be furnished and installed as work of this Division unless shown to be furnished by Division 26. All such wiring shall be in conduit as required by electrical codes. Wiring in the mechanical rooms, fans rooms and inaccessible ceilings and walls shall be installed in conduit as well. Installation of any and all wiring done under Division 21, 22 and 23 shall be in accordance with the requirements of Division 26, Electrical.

B. All equipment that requires an electrical connection shall be furnished so that it will operate properly and deliver full capacity on the electrical service available.

C. Refer to the electrical control equipment and wiring shown on the diagrams. Any changes or additions required by specific equipment furnished shall be the complete responsibility of the Contractor furnishing the equipment.
D. The Mechanical Contractor must coordinate with the Electrical Contractor to insure that all required components of control work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of such coordination.

1.19 WORK, MATERIALS, AND QUALITY OF EQUIPMENT

A. Unless otherwise specified, all materials shall be new and of the best quality of their respective kinds and all labor shall be done in a most thorough and workmanlike manner.

B. Products or equipment of any of the manufacturers cited herein or any of the products approved by the Addenda may be used. However, where lists of products are cited herein, the one first listed in the design equipment used in drawings and schedules to establish size, quality, function, and capacity standards. If other than design equipment is used, it shall be carefully checked for access to equipment, electrical and control requirements, valving, and piping. Should changes or additions occur in piping, valving, electrical work, etc., or if the work of other Contractors would be revised by the alternate equipment, the cost of all changes shall be borne as work of this Division.

C. The Execution portions of the specifications specify what products and materials may be used. Any products listed in the Product section of the specification that are not listed in the Execution portion of the specification may not be used without written approval by the Engineer.

D. The access to equipment shown on the drawings is the minimum acceptable space requirements. No equipment that reduces or restricts accessibility to this or any other equipment will be considered.

E. All major items of equipment are specified in the equipment schedules on the drawings or in these specifications and shall be furnished complete with all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory installation.

F. All welders shall be certified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, latest Edition.

1.20 PROTECTION AGAINST WEATHER AND STORING OF MATERIALS

A. All equipment and materials shall be properly stored and protected against moisture, dust, and wind. Coverings or other protection shall be used on all items that may be damaged or rusted or may have performance impaired by adverse weather or moisture conditions. Damage or defect developing before acceptance of the work shall be made good at the Contractor's expense.

B. All open duct and pipe openings shall be adequately covered at all times.

1.21 INSTALLATION CHECK

A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule and the seismic supplier shall visit the site of the work and inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.
B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated under full load conditions and that it operated satisfactorily.

C. All costs for this work shall be included in the prices quoted by equipment suppliers.

1.22 EQUIPMENT LUBRICATION

A. The Contractor shall properly lubricate all pieces of equipment before turning the building over to the Owner. A linen tag shall be attached to each piece of equipment, showing the date of lubrication and the lubricant used. No equipment shall be started until it is properly lubricated.

B. Necessary time shall be spent with the Owner's Representative to thoroughly familiarize him with all necessary lubrications and maintenance that will be required of him.

C. Detergent oil as used for automotive purposes shall not be used for this work.

1.23 CUTTING AND PATCHING

A. No cutting or drilling in structural members shall be done without written approval of the Architect. The work shall be carefully laid out in advance, and cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces necessary for the mechanical work shall be carefully done. Any damage to building, piping, or equipment shall be repaired by professional plasterers, masons, concrete workers, etc., and all such work shall be paid for as work of this Division.

B. When concrete, grading, etc., is disturbed, it shall be restored to original condition as described in the applicable Division of this Specification.

1.24 EXCAVATION AND BACKFILLING

A. All necessary excavations and backfilling for the Mechanical phase of this project shall be provided as work of this Division. Trenches for all underground pipelines shall be excavated to the required depths. The bottom of trenches shall be compacted hard and graded to obtain required fall. Backfill shall be placed in horizontal layers, not exceeding 12 inches in thickness, and properly moistened. Each layer shall be compacted, by suitable equipment, to a density of not less than 95 percent as determined by ASTM D-1557. After pipelines have been tested, inspected, and approved, the trench shall be backfilled with selected material. Excess earth shall be hauled from the job site. Fill materials approved by the Architect shall be provided as work of this Division.

B. No trenches shall be cut near or under any footings without consultation first with the Architect's office. Any trenches or excavations more than 30 inches deep shall be tapered, shored, covered, or otherwise made absolutely safe so that no vehicle or persons can be injured by falling into such excavations, or in any way be harmed by cave-ins, shifting earth, rolling rocks, or by drowning. This protection shall be extended to all persons approaching excavation related to this work whether or not such persons are authorized to be in the vicinity of the construction.
1.25 ACCESS

A. Provide access doors in walls, ceilings and floors by this division unless otherwise noted. For access to mechanical equipment such as valves, dampers, VAV boxes, fans, controls, etc. Refer to Division 8 for door specifications. All access doors shall be 24" x 24" unless otherwise indicated or required. Coordinate location of doors with the Architect prior to installation. If doors are not specified in Division 8, provide the following: Doors in ceilings and wall shall be equal to JR Smith No. 4760 bonderized and painted. Doors in tile walls shall be equal to JR Smith No. 4730 chrome plated. Doors in floors shall be equal to JR Smith No. 4910

B. Valves: Valve must be installed in locations where access is readily available. If access is compromised, as judged by the Mechanical Engineer, these valves shall be relocated where directed at the Contractors expense.

C. Equipment: Equipment must be installed in locations and orientations so that access to all components requiring service or maintenance will not be compromised. If access is compromised, as judged by the Mechanical Engineer, the contractor shall modify the installation as directed by the Engineer at the Contractors expense.

D. It is the responsibility of this division to install terminal boxes, valves and all other equipment and devices so they can be accessed. If any equipment or devices are installed so they cannot be accessed on a ladder a catwalk and ladder system shall be installed above the ceiling to access and service this equipment.

1.26 CONCRETE BASES AND INSERTS

A. Bases: The concrete bases shall be provided and installed as work by this division. This Division shall be responsible for the proper size and location of bases and shall furnish all required anchor bolts and sleeves with templates to be installed as work of Division 3, Concrete.

B. All floor-mounted mechanical equipment shall be set on 6-inch high concrete bases, unless otherwise noted or shown on drawings. Such bases shall extend 6 inches beyond equipment or mounting rails on all sides or as shown on the drawings and shall have a 1-inch beveled edge all around.

C. Inserts: Where slotted or other types of inserts required for this work are to be cast into concrete, they shall be furnished as work of this Division

D. Concrete inserts and pipe support systems shall be equal to Unistrut P3200 series for all piping where more than one pipe is suspended at a common location. Spacing of the inserts shall match the size and type of pipe and of ductwork being supported. The Unistrut insert and pipe support system shall include all inserts, vertical supports, horizontal support members, clamps, hangers, rollers, bolts, nuts, and any other accessory items for a complete pipe-supporting system.

1.27 CLEANING AND PAINTING

A. Cleaning: After all tests and adjustments have been made and all systems pronounced satisfactory for permanent operation, this Contractor shall clean all exposed piping, ductwork, insulated members, fixture, and equipment installed under this Section and leave them ready for painting. He shall refinish any damaged finish and leave everything in proper working order. The Contractor shall remove all stains or grease marks on walls, floors, glass, hardware, fixtures, or elsewhere, caused by his workman or for which he is responsible. He shall remove
all stickers on plumbing fixtures, do all required patching up and repair all work of others damaged by this division of the work, and leave the premises in a clean and orderly condition.

B. Painting: Painting of exposed pipe, insulated pipe, ducts, or equipment is work of Division 9, Painting.

C. Mechanical Contractor: All equipment which is to be furnished in factory prefinished conditions by the mechanical Contractor shall be left without mark, scratch, or impairment to finish upon completion of job. Any necessary refinishing to match original shall be done. Do not paint over nameplates, serial numbers, or other identifying marks.

D. Removal of Debris, Etc: Upon completion of this division of the work, remove all surplus material and rubbish resulting from this work, and leave the premises in a clean and orderly condition.

1.28 CONTRACT COMPLETION

A. Incomplete and Unacceptable Work: If additional site visits or design work is required by the Engineer or Architect because of the use of incomplete or unacceptable work by the Contractor, then the Contractor shall reimburse the Engineer and Architect for all additional time and expenses involved.

B. Maintenance Instructions: The Contractor shall furnish the Owner complete printed and illustrated operating and maintenance instructions covering all units of mechanical equipment, together with parts lists.

C. Instructions To Owner's Representatives: In addition to any detailed instructions called for, the mechanical Contractor must provide, without expense to the Owner, competent instructors to train the Owner's representatives who will be in charge of the apparatus and equipment, in the care, adjustment, and operation of all parts on the heating, air conditioning, ventilating, plumbing, fire protection, and automatic temperature control equipment. Instruction dates shall be scheduled at time of final inspection. A written report specifying times, dates, and name of personnel instructed shall be forwarded to the Architect. A minimum of four 8-hour instruction periods shall be provided. The instruction periods will be broken down to shorter periods when requested by the Owner. The total instruction hours shall not reduced. The ATC Contractor shall provide 4 hours of instructions. The remaining hours shall be divided between the mechanical and sheet metal Contractor.

D. Guarantee: By the acceptance of any contract award for the work herein described or shown on the drawings, the Contractor assumes the full responsibility imposed by the guarantee as set forth herein and in the General Conditions, and should protect himself through proper guarantees from equipment and special equipment Contractors and from subcontractors as their interests may appear.

E. The guarantee so assumed by the Contractor and as work of this Section is as follows:
1. That the entire mechanical system, including plumbing, heating, and air-conditioning system shall be quiet in operation.
2. That the circulation of water shall be complete and even.
3. That all pipes, conduit, and connections shall be perfectly free from foreign matter and pockets and that all other obstructions to the free passage of air, water, liquid, sewage, and vent shall be removed.
4. That he shall make promptly and free of charge, upon notice from the Owner, any necessary repairs due to defective workmanship or materials that may occur during a period of one year from date of Substantial Completion.
5. That all specialties, mechanical, and patent devices incorporated in these systems shall be adjusted in a manner that each shall develop its maximum efficiency in the operation of the system; i.e., diffusers shall deliver the designed amount of air shown on drawings, thermostats shall operate to the specified limits, etc.

6. All equipment and the complete mechanical, ductwork, piping and plumbing systems shall be guaranteed for a period of one year from the date of the Architect's Certificate of Substantial Completion, this includes all mechanical, ductwork, piping and plumbing equipment and products and is not limited to boiler, chillers, coils, fans, filters etc. Any equipment supplier not willing to comply with this guarantee period shall not submit a bid price for this project. The Contractor shall be responsible for a 100-percent guarantee for the system and all items of equipment for this period. If the contractor needs to provide temporary heating or cooling to the building and or needs to insure systems are installed properly and or to meet the project schedule the guaranteed of all systems and equipment shall be as indicated above, on year from the date of the Architect’s Certificate of Substantial Completion.

7. All filters used during construction shall be replaced just before equipment is turned over to the Owner, and all required equipment and parts shall be oiled. Any worn parts shall also be replaced.

8. If any systems or equipment is used for temporary heating or cooling the systems shall be protected so they remain clean. I.e. if the ductwork systems are used temporary filters and a filter holder (not duct-taped to ducts or grilles) shall be installed to insure the systems and the equipment remain clean.

1.29 CURBS
A. Unless otherwise noted in these specifications or on the documents all roof curbs for all equipment are to be provided by Division 22 and 23.

1.30 TEST RUN
A. The Mechanical Contractor shall operate the mechanical system for a minimum of 30 days to prove the operation of the system.

1.31 EQUIPMENT STARTUP AND CHECKOUT:
A. Each major piece of equipment shall be started and checked out by an authorized representative of the equipment manufacturer. A certificate indicating the equipment is operating to the satisfaction of the manufacturer shall be provided and shall be included in the commissioning report.

B. This contractor shall coordinate commissioning procedures and activities with the commissioning agent.

1.32 DEMOLITION
A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
B. Proceed with demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.

C. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.

D. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.

E. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.

F. Maintain adequate ventilation when using cutting torches.

G. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.

H. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.

I. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.

J. Dispose of demolished items and materials promptly.

K. Return elements of construction and surfaces that are to remain to condition existing before selective demolition operations began.

L. Existing Facilities: Comply with building manager's requirements for using and protecting elevators, stairs, walkways, loading docks, building entries, and other building facilities during selective demolition operations.

M. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

N. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.

O. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, then break up and remove.

P. Air-Conditioning Equipment: Remove equipment without releasing refrigerants.

END OF SECTION 23 0100
SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
7. Grout.
8. Equipment installation requirements common to equipment sections.
10. Concrete bases.
11. Supports and anchorages.
12. Link-Seal

1.3 DEFINITIONS

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

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied
spaces, mechanical equipment rooms, accessible pipe shafts, accessible plumbing chases, and
accessible tunnels.

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

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

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

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PVC: Polyvinyl chloride plastic.
G. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

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

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

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

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

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

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

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

2.4 TRANSITION FITTINGS

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

1. Manufacturers:
a. Eslon Thermoplastics.

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

1. Manufacturers:
   a. Thompson Plastics, Inc.

2.5 DIELECTRIC FITTINGS

A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.

B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.

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

D. Dielectric Unions: Factory-fabricated, union assembly, for \(250\)-psig minimum working pressure at \(180\) deg \(F\).

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

F. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Provide separate companion flanges and steel bolts and nuts for \(150\) or \(300\)-psig minimum working pressure as required to suit system pressures.

G. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and \(300\)-psig minimum working pressure at \(225\) deg \(F\).

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

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Watts Industries, Inc.; Water Products Div

2.6 MECHANICAL SLEEVE SEALS

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

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

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

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

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

2.7 SLEEVES

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

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

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

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

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


2.8 ESCUTCHEONS

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

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

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

D. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

E. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: **5000-psi**, 28-day compressive strength.

### 2.10 LINK-SEAL MODULAR SEAL PRESSURE PLATES

**A.** Link-Seal® modular seal pressure plates shall be molded of glass reinforced Nylon Polymer with the following properties:
   1. Izod Impact - Notched = **2.05ft-lb/in.** per ASTM D-256
   2. Flexural Strength @ Yield = 30,750 psi per ASTM D-790
   3. Flexural Modulus = **1,124,000 psi** per ASTM D-790
   4. Elongation Break = 11.07% per ASTM D-638
   5. Specific Gravity = 1.38 per ASTM D-792

**B.** Models LS200-275-300-315 shall incorporate the most current Link-Seal® Modular Seal design modifications and shall include an integrally molded compression assist boss on the top (bolt entry side) of the pressure plate, which permits increased compressive loading of the rubber sealing element. Models 315-325-340-400-410-425-475-500-525-575-600 shall incorporate an integral recess known as a “Hex Nut Interlock” designed to accommodate commercially available fasteners to insure proper thread engagement for the class and service of metal hardware. All pressure plates shall have a permanent identification of the manufacturer’s name molded into it.

**C.** For fire service, pressure plates shall be steel with 2-part Zinc Dichromate Coating.

**D.** Link-Seal® Modular Seal Hardware: All fasteners shall be sized according to latest Link-Seal® modular seal technical data. Bolts, flange hex nuts shall be:
   1. 316 Stainless Steel per ASTM F593-95, with a **85,000 psi** average tensile strength.

### PART 3 - EXECUTION

#### 3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

**A.** Install piping according to the following requirements and Division 23 Sections specifying piping systems.

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

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

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

**E.** Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

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

   1. New Piping:

      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
      g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.

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

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

   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. PVC Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
1) Seal space outside of sleeve fittings with grout.

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

O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

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

R. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

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

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

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

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

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

3.3 PIPING CONNECTIONS

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

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

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

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

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

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

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

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

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
B. Clean surfaces that will come into contact with grout.
C. Provide forms as required for placement of grout.
D. Avoid air entrapment during placement of grout.
E. Place grout, completely filling equipment bases.
F. Place grout on concrete bases and provide smooth bearing surface for equipment.
G. Place grout around anchors.
H. Cure placed grout.
3.9 LINK SEAL

A. Provide Link Seal at all piping penetrations from the outside.

END OF SECTION 230500
SECTION 230514 - VARIABLE FREQUENCY MOTOR DRIVES

PART 1 - GENERAL

1.1 SUMMARY
A. Includes But Not Limited To:
   1. Furnish and install variable frequency drive (VFD) system with motors as described in
      Contract Documents.

1.2 REFERENCES
A. Institute of Electrical and Electronics Engineers
   1. IEEE 519-1992,

1.3 QUALITY ASSURANCE
A. Requirements: Drive shall meet requirements of IEEE 519 as measured at VFD system
   terminals.
B. Certifications: Completed unit including motor shall be UL or ETL listed and carry appropriate
   label.

1.4 DELIVERY, STORAGE, AND HANDLING
A. Store unit in area free of dirt, vibration, and moisture.
B. Do not allow unit to be exposed to excessive heat or cold.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS
A. General:
   1. Provide VFD and motor one coordinated package, warranted by VFD supplier.
   2. Variable Frequency Drive (VFD) System shall be solid state AC to DC converter
      sineoidal pulse-width modulation (PWM) type.
   3. Unit shall operate on:
      a. Input Voltage Greater than 3 H.P. than 460/3/60 less than 3 H.P> than 230/1/60.
      b. Input frequency 60 Hz, plus or minus 5 percent.
   4. All components of system shall be contained in single enclosure as integrated package.
5. Control power for operator devices and customer connections shall be 120 volts. Control power transformer shall be ‘Machine Tool’ type and have primary and secondary fusing.
6. Variable Frequency Drive shall be rated for continuous current equal to 105 percent of motor FLA.
7. Rated overload current shall be 120 percent for one minute.
8. Unit shall be adjustable accel / decel time setting from one second to 120 seconds.
9. Unit shall maintain 95 percent or better displacement power factor over entire speed range.

B. Enclosure:

1. NEMA 1 force ventilated enclosure with louver covered exhaust ports, hinged doors, and painted with high-grade enamel.
2. Door mounted operator devices shall be industrial, oil tight.
3. Wall mounted or freestanding as shown on Drawings.

C. Variable Frequency Drive Inverter:

1. Altitude compensated and sized for elevation at which unit will be installed.
2. Capable of operating in ambient temperature of 14 deg F to 122 deg F and humidity of 0 percent to 90 percent non-condensing.
3. Mounted on removable panel along with other components so panel can be removed from enclosure for maintenance or part replacement.
4. Output frequency clamp on drive for setting minimum or maximum output frequency.
5. Supply with door interlock input disconnect motor circuit protector. Door mounted handle shall be able to lock in OFF position.

D. Controls And Safety Equipment:

1. Provide, as minimum, following door mounted operator controls:
   a. HAND / OFF / AUTO Switch.
   b. Local / Remote Selector.
   c. Frequency Setting Speed Selector.
   d. Frequency Indication Meter calibrated in percent speed.
   e. Power on Light.
   f. VFD / Bypass Switch.
   g. VFD Fault Light.
   h. External Fault Light (safeties interlock).
   i. Digital Keypad Programmable Parameter Unit (75 hp and less).

2. Provide minimum of following protective features with alarm display indication:
   a. Over-current shut-off.
   b. Regenerative over voltage.
   c. Electronic Thermal Protector.
   d. Heatsink Overheat.
   e. Instantaneous Power Failure.
   f. Output Ground Fault (Actual phase to phase or phase to ground without damage).

3. Provide following termination points on terminal strip for field connections:
   a. Safeties Interlock.
   b. Remote Start / Stop Contact.
   c. Remote VFD Fault Contact.
   d. Remote VFD / Bypass Enable Contact.
e. Remote Electronic Signal Input.

4. Auto Restart shall be initiated by means of automatic time delayed restart after recovering from under voltage or loss of power. Inverter shall not automatically restart after over-current, over-voltage, over-temperature, or other damaging conditions, but shall require manual restart.
   a. Supply inverter with bypass contactor arrangement for transfer to feeder line to operate at constant speed.
   b. Contactors shall be electrically and mechanically interlocked and supplied with adjustable motor overload relay.

5. Provide VFD isolation switch to allow maintenance on VFD while operating in bypass mode. Pre-wired in same enclosure including contactors, input disconnect MCP, motor overload, VFD / Bypass selector switch, and Bypass On light.

6. Provide elapsed time meter.

7. Frequency Jump: Supply drive with capability of being field retrofitted with frequency jump control to avoid operating at point of resonance with natural frequency of machine.

8. Provide VFD unit with computer signal control option through future addition of RS 232 data card.

9. Fault Diagnostics: Drive system shall have non-volatile fault retention so VFDs fault history is available from memory even after power loss.

E. Approved Products:

1. Rockwell Automation, Inc; Allen-Bradley Brand (ABB)

2.2 SOURCE QUALITY CONTROL

A. Before shipping, test each unit and supply certified test report with each unit. Standard test shall include following:

1. Visual inspection consisting of checking unit enclosure, wiring, connections, fasteners, covers, and locking mechanism.

2. High Pot Test:
   a. Apply two times rated voltage plus 1000 volts AC for 60 seconds in accordance with UL 508 on all peripheral drive system power components (circuit breakers, contactors, motor overloads, line reactors, disconnect switches, etc) as complete package.
   b. Include copy of test results in operations manuals.

3. Test devices and lights on control panel devices.

4. Test optional equipment specified with VFD system.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Testing:

1. VFD supplier shall provide three full spectrum harmonic analyses of VFD voltage and current waveforms for each VFD system.
2. Harmonic report shall demonstrate operating harmonic waveforms with VFD’s at 100 percent load, 50 percent load, and with motors operating across line.
3. Conduct harmonic tests at start-up and perform in presence of Architect:
   a. Harmonic current distortion measured at VFD input terminals shall not exceed 40 percent of fundamental current drawn by VFD.
   b. Voltage distortion at this point shall not exceed 3 percent of fundamental.
   c. VFD supplier shall provide harmonic control devices to meet above requirements as integral part of ETL or UL listed VFD system.
   d. Compliance with above limits is strictly responsibility of VFD supplier. Adjustments required to bring system to within specified limits shall be performed at no additional cost to Owner.
   e. Harmonic tests shall be published and included in Operation and Maintenance Manual.
   f. Harmonic distortion compliance shall be approved before final acceptance by Owner.

B. Manufacturer’s Field Services:
   1. Provide field start-up service by authorized factory service representative consisting of system check-out, start-up, and system run.
   2. Provide certificate of completion and authorized factory service including operator training and start-up.

END OF SECTION
SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

   1. Escutcheons.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated or 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.

PART 3 - EXECUTION

3.1 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 with polished, chrome-plated finish.

      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: **One-piece, stamped-steel type with chrome-plated finish.**
d. Bare Piping 2 inch and Smaller at Wall and Floor Penetrations in Finished Spaces: **One-piece, cast-brass** type with polished, chrome-plated finish.
e. Bare Piping Larger than 2 inch at Wall and Floor Penetrations in Finished Spaces: **One-piece, stamped-steel type with polished, chrome-plated finish**
f. Bare Piping 2 inch and Smaller at Ceiling Penetrations in Finished Spaces: **One-piece, cast-brass** type with polished, chrome-plated finish.
g. Bare Piping Larger than 2 inch at Ceiling Penetrations in Finished Spaces: **One-piece, stamped-steel type with polished, chrome-plated finish**
h. Bare Piping 2 inch and Smaller in Unfinished Service Spaces: **One-piece, cast-brass** type.
i. Bare Piping Larger than 2 inch in Unfinished Service Spaces: **One-piece, stamped-steel type with polished, chrome-plated finish**
j. Bare Piping 2 inch and Smaller in Equipment Rooms: **One-piece, cast-brass** type with **polished, chrome-plated** finish.
k. Bare Piping in Equipment Rooms Larger than 2 inch: **One-piece, stamped-steel type with chrome- or cadmium-plated finish.**

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518
SECTION 230519 - METERS AND GAGES FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Liquid-in-glass thermometers.
   2. Thermowells.
   3. Pressure gages.
   4. Gage attachments.
   5. Test plugs.
   6. Test-plug kits.
   7. Flowmeters.

B. Related Sections:
   1. Division 23 Section "Facility Natural-Gas Piping" for gas meters.
   2. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.

1.3 ACTION SUBMITTALS

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

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

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
b. Trerice, H. O. Co.
c. Weiss Instruments, Inc.
d. Weksler.

3. Case: Die Cast aluminum or brass; nominal size unless otherwise indicated.
4. Case Form: Adjustable angle type unless otherwise indicated, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Satin faced, nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Copper-plated steel, aluminum, stainless steel, or brass designed for thermowell installation. Stem shall be of length to match thermowell insertion length.
   
a. Design for Thermowell Installation: Bare stem.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. AMETEK, Inc.; U.S. Gauge Div.
c. Ernst Gage Co.
d. Marsh Bellofram.
e. Miljoco Corp.
f. NANMAC Corporation.
g. Noshok, Inc.
h. Palmer - Wahl Instruments Inc.
i. REO TEMP Instrument Corporation.
j. Tel-Tru Manufacturing Company.
k. Trerice, H. O. Co.
l. Weiss Instruments, Inc.
m. Weksler
n. WIKA Instrument Corporation.
o. Winters Instruments.

2. Manufacturers: Same as manufacturer of thermometer being used.
4. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
5. Material for Use with Copper Tubing: Brass.
7. Type: Stepped shank unless straight or tapered shank is indicated.
8. External Threads: **NPS 1/2, NPS 3/4, NPS 1 or NPS 1-1/4** ASME B1.20.1 pipe threads.
9. Internal Threads: **1/2, 3/4, and 1 inch** with ASME B1.1 screw threads.
10. Bore: Diameter required to match thermometer bulb or stem.
11. Insertion Length: Length required to match thermometer bulb or stem.
12. Lagging Extension: Include on thermowells for insulated piping and tubing.
13. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

### 2.3 PRESSURE GAGES

**A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. KOBOLD Instruments, Inc.
   e. Marsh Bellofram.
   f. Miljoco Corporation.
   g. Noshok.
   h. Palmer Wahl Instrumentation Group.
   i. REOTEMP Instrument Corporation.
   j. Trerice, H. O. Co.
   k. Weiss Instruments, Inc.
   l. Weksler
   m. WIKA Instrument Corporation.
   n. Winters Instruments - U.S.

3. **Case:** Liquid-filled type; cast aluminum or drawn steel; **4-1/2-inch** nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated. **NPS 1/4 or NPS 1/2.**
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Satin faced, nonreflective aluminum with permanently etched scale markings graduated in **psi**.
10. **Ring:** Stainless steel.
11. **Accuracy:** Grade A, plus or minus 1 percent of middle half of scale range.

**B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. KOBOLD Instruments, Inc.
e. Marsh Bellofram.
f. Miljoco Corporation.
g. Noshok.
h. Palmer Wahl Instrumentation Group.
i. REOTEMP Instrument Corporation.
j. Trerice, H. O. Co.
k. Weiss Instruments, Inc.
l. Weksler
m. WIKA Instrument Corporation.
n. Winters Instruments - U.S.

3. **Case:** Liquid-filled, cast aluminum or drawn steel; diameter with back flange for panel surface mounting or front flange for panel recessed mounting. Flanges to include pre-drilled screw holes.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated. **NPS 1/4 or NPS 1/2.**
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Satin faced, nonreflective aluminum with permanently etched scale markings graduated in **psi.**
9. Window: **Glass.**
10. **Ring:** Stainless steel.
11. **Accuracy:** Grade A, plus or minus 1 percent of middle half of scale range.

### 2.4 GAGE ATTACHMENTS

**A.** Snubbers: ASME B40.100, brass; with ASME B1.20.1 pipe threads. Include extension for use on insulated piping. **NPS 1/4 or NPS 1/2.**

1. **Surge-dampening device:** porous-metal-type.

**B.** Siphons:

1. **Loop-shaped section:** Brass pipe with pipe threads. **NPS 1/4 or NPS 1/2.**

**C.** Valves:

1. **Needle:** Brass, with **NPS 1/4 or NPS 1/2** ASME B1.20.1 pipe threads.

### 2.5 TEST PLUGS

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

1. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Twin City Hose.
8. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: or , ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating:

F. Core Inserts: Self-sealing synthetic rubber;
   1. EPDM (Nordel) for air, water or glycol operation between 30 and 275 deg F.
   2. CR (Neoprene) for air, water, glycol, oil, or gas operation between -30 to 200 deg F.

2.6 TEST-PLUG KITS

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

1. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Furnish the number of test-plug kits given below with the number of thermometers given below, with each kit having one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

1. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.
2. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.
3. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be at least 200 psig.
4. Carrying Case: Metal or plastic, with formed instrument padding.
5. One test-plug kit with:
   a. Two thermometers.

2.7 FLOWMETERS

A. Orifice Flowmeters:

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

   a. ABB; Instrumentation and Analytical.
   c. Badger Meter, Inc.; Industrial Div.
   d. Bell & Gossett; ITT Industries.
e. Meriam Process Technologies.
f. Spirax Sarco

2. Description: Flowmeter with sensor, hoses or tubing, quick connect hose fittings, valves, indicator, and conversion chart.

3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.

   a. Design: Differential-pressure-type measurement:
      1) For HVAC hot and chilled water.
   b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
   c. Minimum Pressure Rating: 300 psig.
   d. Minimum Temperature Rating: 250 deg F.

5. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot hoses, with carrying case.
   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.


7. Operating Instructions: Include complete instructions with each flowmeter.

B. Turbine Flowmeters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB; Instrumentation and Analytical.
   b. Data Industrial Corp.
   c. EMCO Flow Systems; a division of Spirax Sarco, Inc.
   d. ERDCO Engineering Corp.
   e. Hoffer Flow Controls, Inc.
   f. Liquid Controls; a unit of IDEX Corporation.
   g. McCrometer, Inc.
   h. Midwest Instruments & Controls Corp.
   i. ONICON Incorporated.
   j. SeaMetrics, Inc.
   k. Sponsler, Inc.; a unit of IDEX Corporation.
   l. Spirax Sarco

2. Description: Flowmeter with sensor and indicator.

3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.

4. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute.
   a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for water.
   b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
   d. Minimum Temperature Rating: 180 deg F.
5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus $1-1/2$ percent.
7. Display: Shows rate of flow, **with register to indicate total volume in gallons**.
8. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pump
   b. Badger Meter, Inc.; Industrial Division
   c. Bailey-Fischer & Porter Co.
   d. Flow Design, Inc.
   e. Gerard Engineering Co.
   f. Hyspan Precision Products, Inc.
   g. Leeds & Northrup.
   h. McCrometer, Inc.
   i. Preso Meters; a division of Racine Federated Inc.
   j. Victaulic Company.
   k. Spirax Sarco

2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, quick connect hose fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   a. Design: Differential-pressure-type measurement for water.
   b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   d. Minimum Temperature Rating: 250 deg F.
   e. End Connections for NPS 2 and Smaller: Threaded.
   f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
   g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

A. **Install thermowells**: with socket extending **one-third of pipe diameter** 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 to most readable position.

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

G. Install needle-valve and snubber in piping for each pressure gage for fluids. Exception: Steam.

H. Install test plugs in piping tees.

I. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer’s written instructions.

J. Install flowmeter elements in accessible positions in piping systems.

K. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer’s written instructions.

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

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

N. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

O. Install thermometers in the following locations:
   1. Inlet and outlet of each hydronic boiler.
   2. Two inlets and two outlets of each chiller.
   3. Inlet and outlet of each hydronic coil in air-handling units.
   4. Two inlets and two outlets of each hydronic heat exchanger.
   5. Inlet and outlet of each thermal-storage tank.
   6. Inlet and outlet of each piece of steam equipment.

P. Install pressure gages in the following locations:
   1. Inlet and discharge of each pressure-reducing valve.
   2. Inlet and outlet of each chilled-water and canal-water connection.
   3. Suction and discharge of each pump.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer’s written instructions.
B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
   1. **Test plug**: With EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
   1. **Industrial**-style, liquid-in-glass type.

C. Thermometers at inlets and outlets of each chiller shall be one of the following:
   1. **Industrial**-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
   1. **Industrial**-style, liquid-in-glass type.

E. Thermometers at inlet and outlet of each hydronic coil at fan coils, cabinet heaters, unit heaters and reheat coils and as shown on details shall be the following:
   1. **Industrial**-style, liquid-in-glass type.
   2. Test plug with [CR] [chlorosulfonated polyethylene synthetic] self-sealing rubber inserts.
   3. Test plug with EPDM self-sealing rubber inserts.

F. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the one of following:
   1. **Industrial**-style, liquid-in-glass type.

G. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be the one of following:
   1. **Industrial**-style, liquid-in-glass type.

H. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
   1. **Industrial**-style, liquid-in-glass type.

I. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: **0 to 100 deg F**.

B. Scale Range for Chilled-Water Piping: **0 to 150 deg F**.

C. Scale Range for Canal-Water Piping: **0 to 150 deg F**.
D. Scale Range for Heating, Hot-Water Piping: **30 to 240 deg F**.

### 3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at inlet and discharge of each pressure-reducing valve shall be the **one of** following:

1. Dry-case type, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each chiller chilled-water and canal-water connection shall be **one of** the following:

1. Liquid-filled, **direct**-mounted, metal case.

C. Pressure gages at suction and discharge of each pump shall be **one of** the following:

1. Liquid-filled, direct-mounted, metal case.

### 3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water, Canal-Water, Heating, and Hot-Water Piping shall be twice the normal operating pressure of the measured system with gage ranges as follows:

1. **30 in. Hg to 15 psi**.
2. **0 to 30 psi**.
3. **0 to 100 psi**.
4. **0 to 160 psi**.
5. **0 to 200 psi**.
6. **0 to 300 psi**.
7. **0 to 600 psi**.

### 3.8 FLOWMETER SCHEDULE

A. Flowmeters: See specification section 230900 Building Automation System.

END OF SECTION 230519
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Bronze ball valves.
      2. Iron, single-flange butterfly valves.
      4. Bronze swing check valves.
      5. Iron swing check valves.
      8. Lubricated plug valves.

   B. Related Sections:
      1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and
         schedules.

1.3 DEFINITIONS
   A. CWP: Cold working pressure.
   B. EPDM: Ethylene propylene copolymer rubber.
   C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
   D. NRS: Nonrising stem.
   E. OS&Y: Outside screw and yoke.
   F. RS: Rising stem.
   G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of valve indicated. Body material, valve design, pressure and
      temperature classification, end connection details, seating materials, trim material and
arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

B. Maintenance data for valves to be included in the operation and maintenance data specified in Division 1. Include detailed manufacturer’s instructions on adjusting, servicing, disassembling, and repairing.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve as listed in SUMMARY from a single source and from a single manufacturer.

B. Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.
   4. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and weld ends.
   3. Set angle, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
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.
   a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg. For, globe, and check valves: below 421 deg. F for ball valves.
3. Threaded: With threads according to ASME B1.20.1.

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

2.2 MANUFACTURERS

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

1. APCO Willamette Valve and Primer Corp.
2. Babbitt Steam Specialty Company.
3. Bray Controls.
4. Center Line.
5. Cla-Val Company.
6. Conbraco Industries Inc.
7. Crane Co.; Crane Valve Group.
8. Fisher Valve by Emerson.
9. Flo Fab Inc.
10. Flow-Tek Inc.
13. Jamesbury; a subsidiary of Metso Automation.
14. Jomar International LTD.
15. Keystone Valve USA, Inc.
16. Kitz Corp.
17. Metraflex Company.
18. Milwaukee Valve Company.
20. NIBCO Inc.
21. Red-White Valve Corp.
23. Stockham Valves and Fittings, Inc.
25. Tyco/Pentair LTD.
27. Victaulic Company.

2.4 **BRONZE BALL VALVES**

C. 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.

2.5 **IRON, SINGLE-FLANGE BUTTERFLY VALVES**

A. 150 CWP, Iron, Single-Flange (Lug) Butterfly Valves:

1. Description:

   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. **Disc:** Nylon 11 coated ductile iron.

B. 175 CWP, Iron, Single-Flange (Lug) Butterfly Valves:

1. Description:

   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 175 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. **Disc:** Nylon 11 coated ductile iron.

C. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and **Nylon 11 coated ductile iron** 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: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Nylon 11 coated ductile iron.

D. 250 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Nylon 11 coated ductile Iron Disc:

   1. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 250 psig.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      e. Seat: EPDM.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Nylon 11 coated ductile iron.

2.6 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valve:

   1. Description:
      b. CWP Rating: 200 psig.
      e. Ends: Threaded.
      f. Disc: Bronze, Type 1.

2.7 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

   1. Description:
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 300 psig.
      c. Body Design: Horizontal flow.
      e. Ends: Threaded.
      f. Disc: Bronze.
2.8 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, 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.

2.9 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Teflon impregnated, asbestos free.
   h. Handwheel: Malleable iron.

2.10 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. Stem: Brass alloy. OS &Y.
   f. Disc: Renewable bronze seat.
   g. Trim: Bronze.
   h. Packing and Gasket: Teflon impregnated, asbestos free.
   i. Handwheel: Cast iron

2.11 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Description:
   a. Standard: MSS SP-78, Type II.
b. **NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.**

c. **Pattern: Regular or short.**
d. **Body Material: ASTM A 48 or ASTM A 126, cast iron with lubrication-sealing system.**
e. **Plug: Cast iron or bronze with sealant groove.**

**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do no proceed with installation until unsatisfactory conditions have been corrected.

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

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

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

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

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

3.2 **VALVE INSTALLATION**

A. Install valves as indicated, according to manufacturer’s written instructions.

B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

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

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

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

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

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.
4. Install all check valves a minimum of five pipe diameters downstream of pump discharge or elbow to avoid flow turbulence. In extreme cases add flow straighteners as required to correct the turbulence.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. **Shutoff Service**: Ball or butterfly valves.
3. **Throttling Service except Steam**: Globe valves.
5. Pump-Discharge Check Valves:
   a. **NPS 2 and Smaller**: Bronze swing check valves with bronze disc.
   b. **NPS 2-1/2 and Larger**: Iron swing check valves with lever and weight or with spring or iron, metal-seat check valves.

6. **Drain Service (except Steam)**: Two-Piece, Full Port Bronze Ball Valves with Bronze Trim. To be installed with NPS ¾ hose thread outlet and hose cap with chain.

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

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. **Bronze Valves**: May be provided with solder-joint ends instead of threaded ends.
3. Ball Valves:
   a. **Piece**: Two
   b. **Port**: Full.
   c. **Material/Trim**: Bronze with:
      1) Bronze trim.
4. Bronze Swing Check Valves:
a. **Class 150**  
   b. **Bronze** disc.

6. **Bronze Globe Valves:**  
   a. **Class 125**  
   b. **Bronze** disc.

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

1. **Iron Valves, NPS 2-1/2 to NPS 4:** May be provided with threaded ends instead of flanged ends.
2. **Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12:**  
   a. 200 CWP,  
   b. **Seat:** EPDM.  
   c. **Disc:** Ductile-iron.
3. **Iron Swing Check Valves:** **Class 125**, metal seats.
4. **Iron Globe Valves:** **Class 125**.
5. **Lubricated Plug Valves:** **Class 125**, regular gland, flanged.

### 3.6 CANAL-WATER VALVE SCHEDULE

A. **Pipe NPS 2 and Smaller:**

1. **Bronze Valves:** May be provided with solder-joint ends instead of threaded ends.
3. **Ball Valves:**  
   a. **Piece:** Two  
   b. **Port:** Full.  
   c. **Material/Trim:** Bronze with:  
      1) **Bronze** trim.
4. **Bronze Swing Check Valves:**  
   a. **Class 150**  
   b. **Bronze** disc.
6. **Bronze Globe Valves:**  
   a. **Class 125**  
   b. **Bronze** disc.

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

1. **Iron Valves, NPS 2-1/2 to NPS 4:** May be provided with threaded ends instead of flanged ends.
2. **Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12:**  
   a. 200 CWP,  
   b. **Seat:** EPDM.  
   c. **Disc:** Ductile-iron.
3. **Iron Swing Check Valves:** **Class 125**, metal seats.
4. **Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12:** **Class 125**, lever and [spring] [weight].
6. **Iron Globe Valves:** **Class 125**.
7. **Lubricated Plug Valves:** **Class 125**, regular gland, flanged.

### 3.7 HEATING-WATER VALVE SCHEDULE

A. **Pipe NPS 2 and Smaller:**
1. **Bronze Valves**: May be provided with solder-joint ends instead of threaded ends.

3. **Ball Valves**:
   a. **Piece**: Two
   b. **Port**: Full.
   c. **Material/Trim**: Bronze with:
      1) Bronze trim.

4. **Bronze Swing Check Valves**:
   a. **Class 150**
   b. Bronze disc.

6. **Bronze Globe Valves**:
   a. **Class 125**
   b. Bronze disc.

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

1. **Iron Valves**, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. **Iron, Single-Flange Butterfly Valves**, NPS 2-1/2 to NPS 12:
   a. 200 CWP,
   b. **Seat**: EPDM.
   c. **Disc**: Ductile-iron.

3. **Iron Swing Check Valves**: Class 125, metal seats.

4. **Iron Globe Valves**: Class 125.

END OF SECTION 230523
SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
B. Related Sections:
1. Division 05 for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS
A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS
A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Trapeze pipe hangers.
2. Metal framing systems.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   d. FNW/Ferguson Enterprises
   e. GS Metals Corp.
   f. Hilti, Inc. insert manufacturer's name.
   h. Thomas & Betts Corporation.
   i. Tolco Inc.
   j. Unistrut; an Atkore International company.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. **Hanger Rods**: Continuous-thread rod, nuts, and washer made of **carbon steel**.
   a. **Electroplated zinc**.

**B. Non-MFMA Manufacturer Metal Framing Systems:**

1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International; a subsidiary of Mueller Water Products, Inc.
   b. Empire Industries, Inc.
   c. ERICO International Corporation.
   d. FNW/Ferguson Enterprises
   e. Haydon Corporation.
   f. NIBCO INC.
   g. PHD Manufacturing, Inc.
   h. PHS Industries, Inc.

2. **Description**: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. **Standard**: Comply with MFMA-4.
4. **Channels**: Continuous slotted steel channel with inturned lips.
5. **Channel Nuts**: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. **Hanger Rods**: Continuous-thread rod, nuts, and washer made of **carbon steel**.
7. **Coating**:
   a. **Zinc**.

### 2.4 THERMAL-HANGER SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.
3. ERICO International Corporation.
5. PHS Industries, Inc.
6. Pipe Shields Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

**B. Insulation-Insert Material for Cold Piping**:
1. **Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psi** minimum compressive strength.

**C. Insulation-Insert Material for Hot Piping**:
1. **Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psi** minimum compressive strength.

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

**E. For Clevis or Band Hangers**: Insert and shield shall cover lower 180 degrees of pipe.
F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 MISCELLANEOUS MATERIALS

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

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 230548 “Vibration and Seismic Controls for HVAC.”

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

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

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

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

F. 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.

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

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

J. 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.

K. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

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

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

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

3.2 METAL FABRICATIONS

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

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.

3.3 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.

3.4 PAINTING

A. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.
B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
F. Use padded hangers for piping that is subject to scratching.
G. Use thermal-hanger shield inserts for insulated piping and tubing.
H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. 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 not necessary.

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 not necessary.

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.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

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

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. 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.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. 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.

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

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

M. 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.

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

O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION 230529
SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

A. Provide engineered vibration isolation and restraint systems in accordance with the requirements of this section including design, engineering, materials, testing, inspections and reports.

B. Mechanical equipment with moving parts shall be mounted on or suspended from vibration isolators to reduce the transmission of vibration and mechanically transmitted sound to the building structure.

C. All mechanical equipment, piping and ductwork shall be restrained as required by Federal, State and Local building codes to preserve the integrity of nonstructural building components during seismic events to minimize hazards to occupants and reduce property damage.

1.3 SUMMARY

A. This Section includes the following:
   1. Elastomeric isolation pads.
   2. Elastomeric isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Open-spring isolators.
   5. Housed-spring isolators.
   6. Restrained-spring isolators.
   8. Pipe-riser resilient supports.
   9. Resilient pipe guides.
  10. Air-spring isolators.
  11. Restrained-air-spring isolators.
  12. Elastomeric hangers.
  13. Spring hangers.
  15. Restraint channel bracings.
  17. Seismic-restraint accessories.
  18. Mechanical anchor bolts.
  19. Adhesive anchor bolts.
  20. Vibration isolation equipment bases.
  22. Certification of seismic restraint designs.
  23. Installation supervision.
  24. Design of attachment of housekeeping pads.
25. All components requiring IBC compliance and certification.
26. All inspection and test procedures for components requiring IBC compliance.
27. Restraint of all mechanical equipment, pipe and ductwork, within, on, or outdoors of the building and entry of services to the building, up to but not including, the utility connection, is part of this Specification.
28. Seismic certification of equipment

1.4 DEFINITIONS

C. ASCE: American Society of Civil Engineers
D. OSHPD: Office of Statewide Health Planning and Development for the State of California.
E. Ip: Importance Factor.
F. ESSENTIAL FACILITIES, (Occupancy Category IV, IBC-2012)
   1. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes.
G. LIFE SAFETY
   1. All systems involved with fire protection, including sprinkler piping, jockey pumps, fire pumps, control panels, service water supply piping, water tanks, fire dampers, smoke exhaust systems and fire alarm panels.
   2. All mechanical, electrical, plumbing or fire protection systems that support the operation of, or are connected to, emergency power equipment, including all lighting, generators, transfer switches and transformers.
   3. All medical and life support systems.
   4. Hospital heating systems and air conditioning systems for maintaining normal ambient temperature.
   5. Automated supply, exhaust, fresh air and relief air systems on emergency control sequence, including air handlers, duct, dampers, etc., or manually-operated systems used for smoke evacuation, purge or fresh air relief by the fire department.
   6. Heating systems in any facility with Occupancy Category IV, IBC-2009 where the ambient temperature can fall below 32 degrees Fahrenheit.

1.5 REFERENCE CODES AND STANDARDS

A. Codes and Standards: The following shall apply and conform to good engineering practices unless otherwise directed by the Federal, State or Local authorities having jurisdiction.
   1. IBC
   2. ASCE 7
3. NFPA 13 (National Fire Protection Association)

B. The following guides may be used for supplemental information on typical seismic installation practices. Where a conflict exists between the guides and these construction documents, the construction documents will preside.


1.6 ISOLATOR AND RESTRAINT MANUFACTURER’S RESPONSIBILITIES:

A. Provide project specific vibration isolation and seismic restraint design prepared by a registered design professional in the state were the project is being constructed, and manufacturer certifications that the components are seismically qualified.

1. Provide calculations to determine restraint loads resulting from seismic forces as required by IBC, Chapter 16 and ASCE 7, latest editions. Seismic calculations shall be certified by an engineer licensed in the state where the project is being constructed.

B. Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.

1. Provide seismic restraint details with specific information relating to the materials, type, size, and locations of anchorages; materials used for bracing; attachment requirements of bracing to structure and component; and locations of transverse and longitudinal sway bracing and rod stiffeners.
2. Provide seismic bracing layout drawings indicating the location of all seismic restraints.
   a. Each piece of rotating isolated equipment shall be tagged to clearly identify quantity and size of vibration isolators and seismic restraints.

C. Provide, in writing, the special inspection requirements for all Designated Seismic Systems as indicated in Chapter 17 of the IBC.

D. Provide training for installation, operation and maintenance of isolation and restraint systems.

1.7 PERFORMANCE REQUIREMENTS

A. Flood-Restraint Loading: Per the structural drawings and specifications.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: Per the structural drawings and specifications.
2. Assigned Occupancy Category as Defined in the IBC: Per the structural drawings and specifications.
   a. Component Importance Factor: 1.5.
      1) Life safety components required to function after an earthquake.
      2) Components containing hazardous or flammable materials in quantities that exceed the exempted amounts for an open system listed in Chapter 4.
      3) For structures with an Occupancy Category IV, components needed for continued operation of the facility or whose failure could impair the continued operation of the facility.
      4) Storage racks in occupancies open to the general public (e.g., warehouse retail stores).
   b. Component Importance Factor: 1.0.
      1) All other components
   c. Component Response Modification Factor: Per the structural drawings and specifications.
   d. Component Amplification Factor: Per the structural drawings and specifications.

3. Design Spectral Response Acceleration at Short Periods: Per the structural drawings and specifications.
4. Design Spectral Response Acceleration at 1-Second Period: Per the structural drawings and specifications.

1.8 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Submittals shall include catalog cut sheets and installation instructions for each type of anchor and seismic restraint used on equipment or components being isolated and/or restrained.
   2. Submittals for mountings and hangers incorporating springs shall include spring diameter and free height, rated load, rated deflection, and overload capacity for each vibration isolation device.
   3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   4. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. “Basis for Design” report: Statement from the registered design professional that the
design complies with the requirements of the ASCE 7-05 Chapter 13, IBC 2009 chapter
1912 and ACI 318. In addition, the basis for compliance must also be noted, as listed
below:

   a. Project specific design documentation prepared and submitted by a registered
design professional (ASCE 7, 13.2.1.1)
   b. Submittal of the manufacturer’s certification that the isolation equipment is
seismically qualified by:
   c. An engineered analysis conforming to the requirements of Chapter 13 of ASCE 7.
   d. Testing by a nationally recognized testing standard procedure such as ICC-ES AC
156.  The substantiated seismic design capacities shall exceed the seismic
demands determined by Section 13.3 of ASCE 7.
   e. Experience data conforming to a nationally recognized procedure.  The
substantiated seismic design capacities shall exceed the seismic demands
determined by Section 13.3 of ASCE 7.

2. Seismic restraint load ratings must be certified and substantiated by testing or
calculations under direct control of a registered professional engineer.  Copies of testing
and calculations must be submitted as part of submittal documents. OSHPD pre-
approved restraint systems are exempt from this requirement if their pre-approval is
current and based upon the IBC 2009 (i.e. OPA-07 pre-approval numbers).

3. Include design calculations and details for selecting vibration isolators, seismic restraints,
and vibration isolation bases complying with performance requirements, design criteria,
and analysis data signed and sealed by the qualified professional engineer responsible
for their preparation.

4. Design Calculations: Calculate static and dynamic loading due to equipment weight and
operation, seismic forces required to select vibration isolators, seismic restraints, and
for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment
mounted outdoors.  Comply with requirements in other Division 23 Sections for
equipment mounted outdoors.

5. Riser Supports: Include riser diagrams and calculations showing anticipated expansion
and contraction at each support point, initial and final loads on building structure, spring
deflection changes, and seismic loads.  Include certification that riser system has been
examined for excessive stress and that none will exist.

6. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and
attachments to structure and to supported equipment. Include auxiliary motor slides and
rails, base weights, equipment static loads, power transmission, component
misalignment, and cantilever loads.

7. Seismic-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic restraints.
Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to
the restrained items and to the structure.  Show attachment locations, methods,
and spacings. Identify components, list their strengths, and indicate directions and
values of forces transmitted to the structure during seismic events.  Indicate
association with vibration isolation devices.
   c. Preapproval and Evaluation Documentation: By an evaluation service member
of ICC-ES, showing maximum ratings of restraint items and the basis for approval
(tests or calculations).
1.9 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

1. Submittal drawings and calculations must be stamped by a registered professional engineer in the State where the project is being constructed who is responsible for the seismic restraint design.
2. Calculations and restraint device submittal drawings shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Concrete anchor locations shall not be near edges, stress joints, or an existing fracture. All bolts shall be ASTM A307 or better.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.10 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.11 SEISMIC CERTIFICATION OF EQUIPMENT

A. Component Importance Factor. All plumbing and mechanical components shall be assigned a component importance factor. The component importance factor, $I_p$, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake.
2. The component contains hazardous materials.
3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.
B. All other components shall be assigned a component importance factor, \( I_p \), equal to 1.0.

C. For equipment or components where \( I_p = 1.0 \):

1. Submit manufacturer’s certification that the equipment is seismically qualified by:
   a. An engineered analysis conforming to the requirements of Chapter 13 of ASCE 7.
   b. Testing by a nationally recognized testing standard procedure such as ICC-ES AC 156. The substantiated seismic design capacities shall exceed the seismic demands determined by Section 13.3 of ASCE 7.
   c. Experience data conforming to a nationally recognized procedure. The substantiated seismic design capacities shall exceed the seismic demands determined by Section 13.3 of ASCE 7.

2. The equipment and components listed below are considered rugged and shall not require Special Seismic Certification:
   a. Valves (not in cast-iron housings, except for ductile cast iron).
   b. Pneumatic operators.
   c. Hydraulic operators.
   d. Motors and motor operators.
   e. Horizontal and vertical pumps (including vacuum pumps).
   f. Air compressors.
   g. Refrigerators and freezers.
   h. Elevator cabs.
   i. Underground tanks.
   j. Equipment and components weighing not more than 20 lbs. supported directly on structures (and not mounted on other equipment or components) with supports and attachments in accordance with Chapter 13, ASCE 7.

3. Rugged equipment and components in this section are for factory assembled discrete equipment and components only and do not apply to site assembled or field assembled equipment or equipment anchorage. The list is based in part on OSHPD Code Application Notice 2-1708A.5.

D. Special Certification requirements for Designated Seismic Systems (i.e. \( I_p = 1.5 \)): Seismic Certificates of Compliance supplied by manufacturers shall be submitted for all components that are part of Designated Seismic Systems. In accordance with the ASCE 7, certification shall be via one of the following methods:

1. For active mechanical and electrical equipment that must remain operable following the design earthquake:
   a. Testing as detailed by part C.1.b above.
   b. Experience data as detailed by part C.1.c above.
   c. Equipment that is considered “rugged” per part C.2 above.

2. Components with hazardous contents shall be certified by the manufacturer as maintaining containment following the design earthquake by:
   a. Testing as detailed by part C.1.b above.
   b. Experience data as detailed by part C.1.c above.
   c. Engineering analysis utilizing dynamic characteristics and forces. Tanks (without vibration isolators) designed by a registered design professional in accordance with ASME Boiler and Pressure Vessel Code, and satisfying the force and
displacement requirements of Sections 13.3.1 and 13.3.2 of ASCE 7 having an
importance factor, \( I_p = 1.0 \) shall be considered to satisfy the Special Seismic
Certification requirements on the basis of ASCE 7 Section 13.6.9.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Amber/Booth Company, Inc.
2. CalDyn (California Dynamics Corporation).
3. ISAT (International Seismic Application Technology).
5. Mason Industries.
6. Vibro-Acoustics
7. VMC (Vibration Mountings & Controls, Inc.)

B. Elastomeric Isolation Pads P1:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading
   over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Ribbed pattern.
5. Load-bearing metal plates adhered to pads.

C. Double-Deflection, Elastomeric Isolation Mounts M1:

1. Mounting Plates:
   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and
      threaded, or with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to
      support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric
   material.

D. Restrained Elastomeric Isolation Mounts M2:

1. Description: All-directional isolator with seismic restraints containing two separate and
   opposing elastomeric elements that prevent central threaded element and attachment
   hardware from contacting the housing during normal operation.
   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric
      material.

E. Spring Isolators S1: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators S2: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation. Baseplates shall limit floor load to 500 psig.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Restrained Spring Isolators S3: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric pad: For high frequency absorption at the base of the spring.

H. Elastomeric Hangers H1:

1. Description: Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods
a. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
b. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

I. Spring Hangers H2: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Description: Combination Coil-Spring and Elastomeric-Insert Hanger with spring and Insert in Compression.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop H3: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Description: Combination Coil-Spring and Elastomeric-Insert Hanger with spring and insert in Compression and vertical limit stop.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support R1:

1. Description: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene.
   a. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
b. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

L. Resilient Pipe Guides R2:

1. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.
   
a. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

M. Horizontal Thrust Restraints T1: Modified specification S2 isolator.

1. Horizontal thrust restraints shall consist of a modified specification S2 spring mounting. Restraint springs shall have the same deflection as the isolator springs.
2. The assembly shall be preset at the factory and fine tuned in the field to allow for a maximum of 1/4" movement from stop to maximum thrust.
3. The assemblies shall be furnished with rod and angle brackets for attachment to both the equipment and duct work or the equipment and the structure.
4. Restraints shall be attached at the center line of thrust and symmetrically on both sides of the unit.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

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

1. Amber/Booth Company, Inc.
2. CalDyn (California Dynamics Corporation).
3. ISAT (International Seismic Application Technology).
5. Mason Industries.
6. Vibro-Acoustics
7. VMC (Vibration Mountings & Controls, Inc.)

B. Restrained Vibration Isolation Roof-Curb Rails: RC1:

C. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

D. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic forces.

E. Lower Support Assembly: The lower support assembly shall be a formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

F. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch-thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are
accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. **Restrained Spring Isolators**: Freestanding, steel, open-spring isolators with seismic and wind restraint.
   
   a. **Housing**: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. **Outside Spring Diameter**: Not less than 80 percent of the compressed height of the spring at rated load.
   c. **Minimum Additional Travel**: 50 percent of the required deflection at rated load.
   d. **Lateral Stiffness**: More than 80 percent of rated vertical stiffness.
   e. **Overload Capacity**: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. **Snubber Bushings**: All-directional, elastomeric snubber bushings at least 1/4 inch-thick.

H. **Water Seal**: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflushed over roof materials.

I. All roof curbs shall be at least 8-inches (MIN) above the roof membrane.

2.3 **VIBRATION ISOLATION EQUIPMENT BASES**

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

1. Amber/Booth Company, Inc.
2. CalDyn (California Dynamics Corporation).
3. ISAT (International Seismic Application Technology).
5. Mason Industries.
6. Vibro-Acoustics
7. VMC (Vibration Mountings & Controls, Inc.)

B. **Steel Bases and Rails SB1**: Factory-fabricated, welded, structural-steel bases and rails.

1. **Design Requirements**: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

   a. Include supports for suction and discharge elbows for pumps.

2. **Structural Steel**: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. **Support Brackets**: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. **Inertia Base IB1**: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than **2-inch** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   
a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

**2.4 SEISMIC-RESTRAINT DEVICES**

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

1. Amber/Booth Company, Inc.
2. CalDyn (California Dynamics Corporation).
3. ISAT (International Seismic Application Technology).
5. Mason Industries.
6. Vibro-Acoustics
7. VMC (Vibration Mountings & Controls, Inc.)

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by **an evaluation service member of ICC-ES**.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

D. Channel Support System: MFMA-4, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement. Cables located in exterior or other wet locations such as wash-down areas shall be stainless steel.
F. **Hanger Rod Stiffener**: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

G. **Hinged and Swivel Brace Attachments**: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

H. **Bushings for Floor-Mounted Equipment Anchor Bolts**: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

I. **Bushing Assemblies for Wall-Mounted Equipment Anchorage**: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

J. **Resilient Isolation Washers and Bushings**: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

K. **Mechanical Anchor Bolts**: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

L. **Adhesive Anchor Bolts**: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

M. All post installed anchors utilized in the seismic design must be qualified for use in cracked concrete and approved for use with seismic loads.

N. **Expansion anchors shall not be used for anchorage of equipment with motors rated over 10 HP with the exception of undercut expansion anchors. Spring or internally isolated equipment are exempt from this requirement.**

O. All beam clamps utilized for vertical support must also incorporate retention straps.

P. All seismic brace arm anchorages to include concrete anchors, beam clamps, truss connections, etc., must be approved for use with seismic loads.

### 2.5 FACTORY FINISHES

A. **Finish**: Manufacturer's standard paint applied to factory-assembled and tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 COORDINATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate size, shape, reinforcement and attachment of all housekeeping pads supporting vibration/seismically rated equipment. Concrete shall have a minimum compressive strength of 4,000 psi or as specified by the project engineer. Coordinate size, thickness, doweling, and reinforcing of concrete equipment housekeeping pads and piers with vibration isolation and seismic restraint device manufacturer to ensure adequate space, embedment and prevent edge breakout failures. Pads and piers must be adequately doweled in to structural slab.

C. Housekeeping pads shall have adequate space to mount equipment and seismic restraint devices.

D. Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors and shall also be large enough and thick enough to ensure adequate edge distance and embedment depth for restraint anchor bolts to avoid housekeeping pad breakout failure. Refer seismic restraint manufacturer’s written instructions.

E. Coordinate with vibration/seismic restraint manufacturer and the structural engineer of record to locate and size structural supports underneath vibration/seismically restrained equipment (e.g. roof curbs, cooling towers and other similar equipment). Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer’s written instructions. Adjust isolators and restraints after piping systems have been filled and equipment is at its operating weight, following the manufacturer’s written instructions.

3.3 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES and per the seismic restraint manufacturer’s design.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.4 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.

C. Isolate all mechanical equipment 0.75 hp and over per the isolator and seismic restraint schedule and these specifications. Vibration isolators shall be selected in accordance with the equipment, pipe or duct weight distribution so as to produce reasonably uniform deflections.

D. All isolation materials and seismic restraints shall be of the same vendor and shall be selected and certified using published or factory certified data.

E. Installation of all vibration isolation materials, flexible connectors and supplemental equipment bases specified in this section shall be accomplished as per the manufacturer’s written instructions with mountings adjusted to level equipment. Any variance or non-compliance with the manufacturer’s instructions shall be reviewed and approved in writing by the manufacturer or corrected by the contractor in an approved manner.

F. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

G. Locate isolation hangers as near to the overhead support structure as possible.

H. No rigid connections between isolated components and the building structure shall be made that degrades the noise and vibration control system herein specified. “Building” includes, but is not limited to, slabs, beams, columns, studs and walls. “Components” includes, but is not limited to, mechanical equipment, piping and ducts.

I. Coordinate work with other trades to avoid rigid contact with the building.

J. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

K. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor’s expense.

L. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor’s expense.

M. Use horizontal thrust restraints T1 to protect Air handling equipment and centrifugal fans against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight.
N. Isolated equipment, duct and piping located on roofs must be attached to the structure. Supports (e.g., sleepers) that are not attached to the structure will not be acceptable.

O. On completion of installation of all isolation materials and before startup of isolated equipment all debris shall be cleared from areas surrounding and from beneath all isolated equipment, leaving equipment free to move on the isolation supports.

P. All floor mounted isolated equipment shall be protected with specification M1, M2, S1, S2 or S3 isolator.

Q. Horizontal Pipe Isolation: All HVAC pumped water, pumped condensate, glycol, and refrigerant piping size 1-1/4" and larger within mechanical rooms shall be isolated. Outside equipment rooms this piping shall be isolated for the greater of 50’ or 100 pipe diameters from rotating equipment. For the first three (3) support locations from externally isolated equipment provide specification H2 or H3 hangers or specification S1, S2 or S3 mounts with the same deflection as equipment isolators (max 2”). All other piping within the equipment rooms shall be isolated with the same specification isolators with a 3/4” minimum deflection. Steam piping size 1-1/4” and larger which is within an equipment room and connected to rotating equipment shall be isolated for three (3) support locations from the equipment. Provide specification H2 or H3 hangers, or specification S1 or S2 mounts with the same deflection as equipment isolators but a minimum of ¾”.

R. Install full line size flexible pipe connectors at the inlet and outlet of each pump, cooling tower, condenser, chiller, coiling connections and where shown on the drawings. All connectors shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit elongation to 3/8”. Flexible connectors shall not be required for suspended in-line pumps.

S. All plumbing pumped water, piping size 1-1/4” and larger within mechanical rooms shall be isolated the same as HVAC piping above. Isolators are not required for any plumbing pumped water, pumped condensate, and steam piping outside of mechanical rooms unless listed in the isolation schedule.

T. Pipe Riser Isolation: The operating weight of all variable temperature vertical pipe risers 1-1/4” and larger, requiring isolation where specifically shown and detailed on riser drawings shall be fully supported by specification M1, M2 or R1 supports. S1, S2, S3, H2 or H3 steel spring deflection isolators with minimum 3/4-inch minimum shall be in those locations where added deflection is required due to pipe expansion and contraction. Spring deflection shall be a minimum of 4 times the anticipated deflection change. Springs shall be selected to keep the riser in tension. Height saving brackets used with isolators having 2.5” deflection or greater shall be of the precompression type to limit exposed bolt length. Specification R1 riser supports shall be installed near the center point of the riser to anchor the riser when spring isolation is used. Specification R2 riser guides may be used in conjunction with spring isolators per design calculations. Pipe risers up through 16” shall be supported at intervals of every third floor of the building. Pipe risers 18” and over, every second floor. Wall sleeves for take-offs from riser shall be sized for insulation O.D. plus two times the anticipated movement to prevent binding. Horizontal take-offs and at upper and lower elbows shall be supported with spring isolators as required to accommodate anticipated movement. In addition to submittal data requirements previously outlined, riser diagrams and calculations shall be submitted for approval. Calculations must show anticipated expansion and contraction at each support point, initial and final loads on the building structure, and spring deflection changes. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist if installed per design proposed.
U. Where riser pipes pass through cored holes, core diameters shall be a maximum of 2” larger than pipe O.D. including insulation. Cored holes must be packed with resilient material or firestop as provided by other sections of this specification or local codes. Where seismic restraint is required specification isolator S3 shall support risers and provide longitudinal restraint at floors where thermal expansion is minimal and will not bind isolator restraints.

V. Duct Isolation: Isolate all duct work with a static pressure 2” W.C. and over in equipment rooms and to minimum of 50 feet from the fan or air handler. Use specification type H2 or H3 hangers or type S1 or S2 floor mounts.

3.5 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. On projects with Seismic Site Class A or B, seismic design or restraint is not required.

2. On projects with Seismic Design Category C: Components with an importance factor of 1.0 do not require seismic design or restraint.

3. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

4. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

5. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

6. Suspended Equipment: All suspended equipment that meets any of the following conditions requires seismic restraints as specified by the supplier:

   a. Rigidly attached to pipe or duct that is 75 lbs. and greater,

   b. Items greater than 20 lbs and distribution systems weighing more than 5 lbs/lineal foot, with an importance factor of 1.0 hung independently or with flexible connections.

   c. Possibility of consequential damage.

   d. For importance factors greater than 1.0 all suspended equipment requires seismic restraint regardless of the above notes.

   e. Wall mounted equipment weighing more than 20 lbs.

   f. Exemptions:

      1) Equipment weighing less than 20 lbs and distribution systems weighing less than 5 lbs/lineal foot, with an Ip = 1.0 and where flexible connections exist between the component and associated ductwork, piping or conduit.

7. Base Mounted Equipment: All base mounted equipment that meets any of the following conditions requires attachments and seismic restraints as specified by the supplier:

   a. Connections to or containing hazardous material,

   b. With an overturning moment.

   c. Weight greater than 400 lbs.

   d. Mounted on a stand 4 ft. or more from the floor

   e. Possibility of consequential damage.
Logan City School District - Ellis Elementary School

f. For importance factors greater than 1.0 all base mounted items require seismic restraints regardless of the above notes.
g. For equipment with high center of gravity additional cable restraints shall be furnished, as required by isolation manufacturer, to limit forces and motion caused by rocking.
h. Exemptions:

1) Floor or curb-mounted equipment weighing less than 400 lbs and not resiliently mounted, where the Importance Factor, Ip = 1.0, the components are mounted at 4 feet or less above a floor level, flexible connections between the components and associated duct work, piping and conduit are provided and there is no possibility of consequential damage.

8. Roof Mounted Equipment:
a. To be installed on a structural frame, seismically rated roof curb, or structural curb frame mechanically connected to the structure. Items shall not be mounted onto sleepers or pads that are not mechanically and rigidly attached to the structure. Restraint must be adequate to resist both seismic and wind forces.
b. Roof curbs shall be installed directly to building structural steel or concrete roof deck and not to top of steel deck or roofing material.
c. Exemptions:

1) Curb-mounted mushroom, exhaust and vent fans with curb area less than nine square feet are excluded.

9. Rigid Mounted Equipment:
a. Anchor floor and wall mounted equipment to the structure as per the stamped seismic certifications / drawings.
b. For equipment with high center of gravity additional cable restraints shall be furnished, as required by isolation manufacturer, to limit forces and motion caused by rocking.
c. Suspended equipment shall be restrained using seismic cable restraints, or struts, and hanger rods as per the stamped seismic certifications / drawings.

10. Vibration Isolated Equipment:
a. Seismic control shall not compromise the performance of noise control, vibration isolation or fire stopping systems.
b. Equipment supported by vibration-isolation hangers shall be detailed and installed with approximately a 1/8" gap between the isolation hangers and the structure. Isolators at restraint locations must be fitted with uplift limit stops.

B. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

C. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

D. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

E. Installation and adjustment of all seismic restraints specified in this section shall be accomplished as per the manufacturer’s written instructions. Any deviation from the manufacturer’s instructions shall be reviewed and approved by the manufacturer.
F. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   4. Seismically restrain piping, with an Ip = 1.0, located in boiler rooms, mechanical equipment rooms and refrigeration equipment rooms that is 1½” I.D. and larger.
   5. Seismically restrain all other Ip = 1.0 piping 2½” diameter and larger.
   6. Seismically restrain all Ip = 1.5 piping larger than 1” diameter.
   7. Branch lines may not be used to brace main lines.
   8. Exemptions:
      a. All high deformability pipe 3” or less in diameter suspended by individual hanger rods where Ip = 1.0.
      b. High deformability pipe or conduit in Seismic Design Category C, 2” or less in diameter suspended by individual hanger rods where Ip = 1.5.
      c. High deformability pipe in Seismic Design Category D, E or F, 1” or less in diameter suspended by individual hanger rods where Ip = 1.5.
      d. All clevis supported pipe runs installed less than 12” from the top of the pipe to the underside of the support point and trapeze supported pipe suspended by hanger rods having a distance less than 12” in length from the underside of the pipe support to the support point of the structure.
      e. Piping systems, including their supports, designed and constructed in accordance with ASME B31.
      f. Piping systems, including their supports, designed and constructed in accordance with NFPA, provided they meet the force and displacement requirements of Section 13.3.1 and 13.3.2 (ASCE 7).
   G. Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement.
   H. Install flexible piping connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.
   I. Where pipe sizes reduce below dimensions required for seismic, the final restraint shall be installed at the transition location.
   J. Restraint Spacing For Piping: Sizes shown are maximum. Actual spacing determined by calculation.
      1. For non-ductile piping (e.g., cast iron, PVC) space transverse supports a maximum of 20’ o.c., and longitudinal supports a maximum of 40’ o.c.
      2. For piping with hazardous material inside (e.g., natural gas, medical gas) space Transverse supports a maximum of 20’ o.c., and longitudinal supports a maximum of 40’ o.c.
      3. For pipe risers, restrain the piping at floor penetrations using the same spacing requirements as above.
      4. For all other ductile piping see Table “A” below
   K. Seismic Restraint of Ductwork: Seismically restrain per specific code requirements, all ductwork listed below (unless otherwise indicated on the drawings), using seismic cable restraints: (Ductwork not meeting criteria listed below is to be “Exempt”)
1. Restrain rectangular ductwork with cross sectional area of 6 square feet or larger. Duct with an importance factor of 1.5 must be braced with no exceptions regardless of size or distance requirements.
2. Restrain round ducts with diameters of 28” or larger. Duct with an importance factor of 1.5 must be braced with no exceptions regardless of size or distance requirements.
3. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
4. Duct must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze. Additional reinforcing is not required if duct sections are mechanically fastened together with frame bolts and positively fastened to the duct support suspension system.
5. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
6. Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.
7. If ducts are supported by angles, channels or struts, ducts shall be fastened to it at seismic brace locations in lieu of duct reinforcement.
8. All ductwork weighing more than 17 lb/ft.
9. Exemptions:
   a. Duct runs supported at locations by two rods less than 12 inches in length from the structural support to the structural connection to the ductwork. This exemption does not apply to ducts with an importance factor of 1.5.
10. See Table “A” below for restraint spacing.

L. Exemptions do not apply for:
1. Life Safety or High Hazard Components
   a. Including gas, fire protection, medical gas, fuel oil and compressed air needed for the continued operation of the facility or whose failure could impair the facility’s continued operation, Occupancy Category IV, IBC-2009 as listed in Section 1.3 B regardless of governing code for HVAC, Plumbing, Electrical piping or equipment. (A partial list is illustrated.) High Hazard is additionally classified as any system handling flammable, combustible or toxic material. Typical systems not excluded are additionally listed below.
2. Piping
   a. Fuel oil, gasoline, natural gas, medical gas, steam, compressed air or any piping containing hazardous, flammable, combustible, toxic or corrosive materials. Fire protection standpipe, risers and mains. Fire Sprinkler Branch Lines must be end tied.
3. Duct
   a. Smoke evacuation duct or fresh air make up connected to emergency system, emergency generator exhaust, boiler breeching or as used by the fire department on manual override.
4. Equipment
a. Previously excluded non life safety duct mounted systems such as fans, variable air volume boxes, heat exchangers and humidifiers having a weight greater than 75 lbs require independent seismic bracing.

M. Spacing Chart For Suspended Components:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>On Center Transverse</th>
<th>On Center Longitudinal</th>
<th>Change Of Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct</td>
<td>30 Feet</td>
<td>60 Feet</td>
<td>4 Feet</td>
</tr>
<tr>
<td>Pipe Threaded, Welded, Soldered Or Grooved</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>To 16”</td>
<td>40 Feet</td>
<td>80 Feet</td>
<td>4 Feet</td>
</tr>
<tr>
<td>18” – 28”</td>
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<td>4 Feet</td>
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<td>30” – 40”</td>
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<td>60 Feet</td>
<td>4 Feet</td>
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<tr>
<td>42” &amp; Larger</td>
<td>10 Feet</td>
<td>30 Feet</td>
<td>4 Feet</td>
</tr>
</tbody>
</table>

N. Roof mounted duct is to be installed on sleepers or frames mechanically connected to the building structure. Roof anchors and seismic cables or frames shall be used to resist seismic and wind loading. Wind loading factors shall be determined by the registered design professional.

O. Where duct sizes reduce below dimensions required for seismic restraint the final restraint shall be installed at the transition location.

P. Install cables so they do not bend across edges of adjacent equipment or building structure.

Q. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

R. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

S. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

T. Seismically Rated Beam Clamps are required where welding to or penetrations to steel beams are not approved.

U. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.

3.7 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

1. A representative of the vibration isolation system manufacturer shall review the project installation and provide documentation indicating conformance to vibration isolation design intent.

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

D. Prepare test and inspection reports.

1. The installing contractor shall submit a report upon request to the building architect and/or engineer, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the contractor to properly complete the seismic restraint work as per the specifications.

3.8 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

1. Adjust active height of spring isolators.

C. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>A' LOCATION CRITICAL (35'-50' SPAN)</th>
<th>B' UPPER STORY (20'-35' SPAN)</th>
<th>C' GRADE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ISOLATOR MINIMUM DEFLECTION (IN)</td>
<td>BASE ISOLATOR MINIMUM DEFLECTION (IN)</td>
<td>BASE ISOLATOR MINIMUM DEFLECTION (IN)</td>
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<td><strong>EQUIPMENT (1)</strong></td>
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<tr>
<td><strong>AIR HANDLING UNITS</strong></td>
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<td>FLOOR MOUNTED</td>
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<tr>
<td>UP TO 15 HP</td>
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<td>S3 0.75</td>
<td>S3 0.75</td>
</tr>
<tr>
<td>20 HP &amp; OVER</td>
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<td>SUSPENDED</td>
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<td>UP TO 15 HP</td>
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<td>H3 1</td>
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<td>40 HP &amp; OVER</td>
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<td><strong>CABINET FANS, FANS SECTIONS</strong></td>
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119291 Ellis Elementary 230548 - 24 VIBRATION AND SEISMIC CONTROLS FOR HVAC
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<tr>
<td>Air Compressors</td>
<td>S1</td>
<td>2.5</td>
<td>IB1</td>
<td>S3</td>
<td>1.5</td>
<td>S3</td>
<td>0.75</td>
<td>IB1</td>
<td></td>
</tr>
<tr>
<td>Tank Type (Horizontal Tank)</td>
<td>S1</td>
<td>2.5</td>
<td>IB1</td>
<td>S3</td>
<td>1.5</td>
<td>IB1</td>
<td>S3</td>
<td>0.75</td>
<td>IB1</td>
</tr>
<tr>
<td>Tank Type (Vertical Tank)</td>
<td>S3</td>
<td>2.5</td>
<td>S3</td>
<td>1.5</td>
<td>IB1</td>
<td>P1</td>
<td>0.15</td>
<td></td>
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<tr>
<td>Cooling Towers &amp; Closed Circuit Coolers</td>
<td>S3</td>
<td>2.5</td>
<td>S3</td>
<td>0.75</td>
<td>P1</td>
<td>0.15</td>
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<td>Air Cooled Condensers</td>
<td>S3</td>
<td>2.5</td>
<td>S3</td>
<td>1.5</td>
<td>P1</td>
<td>0.15</td>
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<td>Rooftop Air Conditioning Units</td>
<td>S3</td>
<td>2.5</td>
<td>S3</td>
<td>0.75</td>
<td>P1</td>
<td>0.15</td>
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<td>Requiring Weather Seal</td>
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<td>Up to 5000 CFM (12 TON)</td>
<td>S3</td>
<td>1.5</td>
<td>RC1</td>
<td>S3</td>
<td>0.75</td>
<td>RC1</td>
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<td>Other Types</td>
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<tr>
<td>Up to 25 TONS</td>
<td>S3</td>
<td>1.5</td>
<td>S3</td>
<td>1.5</td>
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<tr>
<td>Over 25 TONS</td>
<td>S3</td>
<td>2.5</td>
<td>S3</td>
<td>1.5</td>
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<td>Boiler (Package Type)</td>
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<tr>
<td>Engine Driven Generators</td>
<td>S1</td>
<td>2.5</td>
<td>IB1</td>
<td>S3</td>
<td>1.5</td>
<td>IB1</td>
<td>S3</td>
<td>0.75</td>
<td>IB1</td>
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<tr>
<td>Up to 60 HP</td>
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<td>75 HP &amp; OVER</td>
<td>S1</td>
<td>3.5</td>
<td>IB1</td>
<td>S3</td>
<td>2.5</td>
<td>IB1</td>
<td>S3</td>
<td>0.75</td>
<td>IB1</td>
</tr>
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**NOTES:**

1) Thrust restraints required on all high-pressure fan section, suspended axial-flow fans and on floor-mounted axial fans operating at 3.0" S.P. or greater.

END OF SECTION 230548
SECTION 230550 - OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. All pertinent sections of Division 21, 22, & 23 Mechanical General Requirements, are part of the work of this Section. Division 1 is part of this and all other sections of these specifications.

1. Testing and Balancing is specified in section 230594.
2. Training and Instructions to Owner’s Representative is specified in section 230100.

1.2 SCOPE OF WORK

A. Submission of Operating and Maintenance Manuals complete with Balancing reports. (Coordinate with Division 1).

B. Coordination of work required for system commissioning.

C. Provide a hard copy and an electronic copy on CD of the O and M manual fully searchable in PDF format.

1.3 SUBMITTALS

A. Submit product data in accordance with Division 1 and Section 230100. Submit the following:

2. Hard copy and an electronic copy on CD of the O and M manual fully searchable in PDF format. Both the hard copy and the electronic copy are to be fully indexed. The electronic copy shall also have a linked index.

PART 2 - PRODUCTS

2.1 O & M MANUALS

A. The operating and maintenance manuals shall be as follows:

1. Binders shall be red buckram with easy-view metal for size 8-1/2 x 11-inch sheets, with capacity expandable from 2 inches to 3-1/2 inches as required for the project. Construction shall be rivet-through with library corners. No. 12 backbone and lining shall be the same material as the cover. The front cover and backbone shall be foil-stamped in white as follows: (coordinate with Division 01 )

OPERATING AND MAINTENANCE MANUAL
FOR THE

(INsert PROJECT NAME)

119291 Ellis Elementary 230550 - 1 OPERATION AND MAINTENANCE OF HVAC SYSTEMS
PART 3 - EXECUTION

3.1 OPERATING AND MAINTENANCE MANUALS:

A. Work under this section shall be performed in concert with the contractor performing the system testing and balancing. Six (6) copies of the manuals shall be furnished to the Architect for distribution to the owner.

B. The "Start-Up and Operation" section is one of the most important in the manual. Information in this section shall be complete and accurately written and shall be verified with the actual equipment on the job, such as switches, starters, relays, automatic controls, etc. A step-by-step start-up procedure shall be described.

C. The manuals shall include air and water-balancing reports, system commissioning procedures, start-up tests and reports, equipment and system performance test reports, warranties, and certificates of training given to the owner’s representatives.

An index sheet typed on AICO Gold-Line indexes shall be provided in the front of the binder. The manual shall include the following:

SYSTEM DESCRIPTIONS

START-UP PROCEDURE AND OPERATION OF SYSTEM

MAINTENANCE AND LUBRICATION TABLE

OPERATION AND MAINTENANCE BULLETINS

AUTOMATIC TEMPERATURE CONTROL DESCRIPTION OF OPERATION, INTERLOCK AND CONTROL DIAGRAMS, AND CONTROL PANELS.

AIR AND WATER SYSTEM BALANCING REPORTS

EQUIPMENT WARRANTIES AND TRAINING CERTIFICATES

SYSTEM COMMISSIONING REPORTS

EQUIPMENT START-UP CERTIFICATES
SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Equipment labels.
      2. Danger, Warning and Caution signs and labels.
      3. Pipe labels.
      4. Duct labels.
      5. Stencils.
      6. Valve tags.
      7. Danger tags.
      8. Warning tags.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
   C. Valve numbering scheme.
   D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION
   A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   B. Coordinate installation of identifying devices with locations of access panels and doors.
   C. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Minimum Thickness, predrilled or stamped holes for attachment hardware:
      a. Brass, 0.032-inch.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   4. Fasteners: Stainless-steel;
      a. Rivets or self-tapping screws
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, and having predrilled holes for attachment hardware, 1/16 inch thick.
   2. Letter Color:
      a. Black.
   3. Background Color:
      a. White.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel;
      a. Rivets or self-tapping screws
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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

2.2 DANGER, WARNING AND CAUTION SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, having predrilled holes for attachment hardware; 1/16 inch thick.
B. Danger signs, colors:
   1. Letter Color:
      a. White.
   2. Background Color:
      a. Red.

C. Warning signs, colors:
   1. Letter Color:
      a. Black.
   2. Background Color:
      a. Orange.

D. Caution signs, colors:
   1. Letter Color:
      a. Black.
   2. Background Color:
      a. Yellow.

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

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

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

H. Fasteners: Stainless-steel;
   1. Rivets or self-tapping screws
   2. Rivets.

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

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

2.3 PIPE LABELS

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

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

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.
2.4 DUCT LABELS

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

B. Letter Color:
   1. White.

C. Background Color:
   1. Black.

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

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

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

G. Fasteners: Stainless-steel;
   1. 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, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

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

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

119291 Ellis Elementary  230553- 4  IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
1. Tag Material, predrilled or stamped holes for attachment hardware, minimum thickness:
   a. Brass, 0.032-inch

2. Fasteners: Brass;
   a. Wire-link or beaded chain; or S-hook

B. Valve Schedules:

1. For each piping system, on 8-1/2-by-11-inch bond paper, tabulate;
   a. Valve number.
   b. Piping system.
   c. System abbreviation (as shown on valve tag).
   d. Location of valve (room or space).
   e. Normal-operating position (open, closed, or modulating).
   f. Variations for identification.
   g. Mark valves for emergency shutoff and similar special uses.

2. Valve-tag schedule:
   a. Shall be included in operation and maintenance data.

2.7 DANGER TAGS

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

1. Size:
   a. 3 by 5-1/4 inches minimum

2. Fasteners:
   a. Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as "DANGER," and "DO NOT OPERATE."


2.8 WARNING TAGS

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

1. Size:
   a. 3 by 5-1/4 inches minimum

2. Fasteners:
   a. Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as "WARNING" and "DO NOT OPERATE."


2.9 CAUTION TAGS

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

1. Size:
   a. 3 by 5-1/4 inches minimum
2. Fasteners:
   a. Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "CAUTION," and "DO NOT OPERATE."

2.10 CEILING GRID
A. Provide red lettering on the ceiling tile grid of the locations of all fire dampers, smoke dampers and fire/smoke dampers. Size of lettering and verbiage is to conform to IBC and NFPA standards.
B. Provide valve identification for all HVAC valves located above the ceiling on the ceiling grid below the valve.
C. Provide VAV box identification for all VAV boxes located above the ceiling on the ceiling grid below the VAV box.

PART 3 - EXECUTION

3.1 PREPARATION
A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION
A. Install or permanently fasten labels on each major item of mechanical equipment.
B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION
A. Piping Color-Coding: Painting of piping is specified in Division 09.
B. Stenciled Pipe Label Option:
   1. Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option.
   2. Install stenciled pipe labels with painted, color-coded bands or rectangles on each piping system.
      b. Stencil Paint: Use for pipe marking.
C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
IDENTIFICATION FOR HVAC PIPING

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

D. Pipe Label Color Schedule: (See Drawing Schedules)

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated 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 concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION (See Drawing Schedules.)

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 230553
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:
   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.
   c. Primary-secondary hydronic systems.

3. Various HVAC Equipment.
   b. Motors.
   c. Condensing Units.
   d. Boilers.
   e. Heat Transfer Coils.


1.3 DEFINITIONS


C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.
1.4 INFORMATIONAL SUBMITTALS

Qualification Data: Within the following number of days of the Contractor’s Notice to Proceed, submit documentation that the TAB contractor and this Project’s TAB team members meet the qualifications specified in “Quality Assurance” Article;

1. 30 days.

B. Certified TAB reports.

C. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB and shall be the same as the TAB Contractor.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician and shall be the same as the TAB Contractor.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor’s forms approved by:

1. Architect.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner’s operations.

1.7 COORDINATION

A. Notice: Provide [seven] days’ advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on the following distribution systems have been satisfactorily completed:
PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:

1. Bonneville Test and Balance
2. BTC Service.
3. Certified Test & Balance.
5. RS Analysis.
6. Test & Balance Inc.
7. Payson Sheetmetal.
8. QT&B Inc.

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems’ designs that may preclude proper TAB of systems and equipment.

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

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

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

E. Examine:
   1. Ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in:
      a. Section 233113 "Metal Ducts"
   2. Verify ceiling plenums and underfloor air plenums used for supply, return or relief air are properly separated from adjacent areas.
   3. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

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

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

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

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

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

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

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

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

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

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

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

   1. Permanent electrical-power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
   7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in this section and:

   1. AABC’s "National Standards for Total System Balance"
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. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

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

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

### 3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

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

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

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

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

### 3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

6. Obtain approval from one of the following entities 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:
   a. Architect.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

   1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure 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.
   3. Measure total system airflow. Adjust to within indicated airflow.
   4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
   5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
      a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
   6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
   8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

   1. Balance variable-air-volume systems the same as described for constant-volume air systems.
   2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

4. Readjust fan airflow for final maximum readings.

5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.

6. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.

3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow.

6. Measure static pressure at the sensor.

7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

   a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from the following entity and comply with requirements in Section 232123 "Hydronic Pumps."

      1) Architect.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

   a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.11 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.12 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

3.13 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.
3.14 PROCEDURES FOR CONDENSING UNITS
A. Verify proper rotation of fans.
B. Measure entering- and leaving-air temperatures.
C. Record compressor data.

3.15 PROCEDURES FOR BOILERS
A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS
A. Measure, adjust, and record the following data for each water coil:
   1. Entering- and leaving-water temperature.
   2. Water flow rate.
   3. Water pressure drop.
   4. Dry-bulb temperature of entering and leaving air.
   5. Wet-bulb temperature of entering and leaving air for cooling coils.
   6. Airflow.
   7. Air pressure drop.
B. Measure, adjust, and record the following data for each electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.
C. Measure, adjust, and record the following data for each steam coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.
D. Measure, adjust, and record the following data for each refrigerant coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Wet-bulb temperature of entering and leaving air.
   3. Airflow.
   4. Air pressure drop.
   5. Refrigerant suction pressure and temperature.
3.17 DOMESTIC HEATER SYSTEMS
   
   A. Test domestic heater system per Engineer’s instructions.

3.18 TOLERANCES
   
   A. Set HVAC system’s air flow rates and water flow rates within the following tolerances:

   1. Supply, Return, and Exhaust Fans and Equipment with Fans: **Plus or minus 10 percent**.
   2. Air Outlets and Inlets: **Plus or minus 10 percent**.
   3. Heating-Water Flow Rate: **Plus or minus 10 percent**.
   4. Cooling-Water Flow Rate: **Plus or minus 10 percent**.

3.19 REPORTING
   
   A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems’ balancing devices. Recommend changes and additions to systems’ balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

   B. Status Reports: Prepare progress reports on the following interval to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors;

   1. **Weekly**.

3.20 FINAL REPORT
   
   A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.

   B. Final Report Contents: In addition to certified field-report data, include the following:

   1. Pump curves.
   2. Fan curves.
   3. Manufacturers’ test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and product data.

   C. General Report Data: In addition to form titles and entries, include the following data:

   1. Title page.
   2. Name and address of the TAB contractor.
   3. Project name.
Logan City School District - Ellis Elementary School

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. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

   1. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Water and steam flow rates.
   3. Duct, outlet, and inlet sizes.
   4. Pipe and valve sizes and locations.
   5. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches, and bore.
      i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
      j. Number, make, and size of belts.
      k. Number, type, and size of filters.
2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

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

F. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btu/h.
   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 air flow 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.

H. 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. Air flow 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. Air flow 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.

I. 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.

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

K. Air-Terminal-Device Reports:

1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Apparatus used for test.
   d. Area served.
   e. Make.
   f. Number from system diagram.
   g. Type and model number.
   h. Size.
   i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Air velocity in fpm.
   c. Preliminary air flow rate as needed in cfm.
   d. Preliminary velocity as needed in fpm.
   e. Final air flow rate in cfm.
   f. Final velocity in fpm.
   g. Space temperature in deg F.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:
   a. System and air-handling-unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.21 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by:
   a. Architect.

2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of:
   a. Architect.

3. The following entity 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:
   a. Architect.

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

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

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.22 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.

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SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, 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.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation
duct insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Sheet, K-Flex Gray Duct Liner, and K-FLEX LS.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, **Type III with factory-applied FSK jacket**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with **factory-applied ASJ**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; Commercial Board.
      b. Fibrex Insulations Inc.; FBX.
      c. Johns Manville; 800 Series Spin-Glas.
      d. Knauf Insulation; Insulation Board.
      e. Manson Insulation Inc.; AK Board.
      f. Owens Corning; Fiberglas 700 Series.
I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Armacell LLC; Tubolit.
   b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a:
   a. 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction

1. Products: Subject to compliance with requirements, provide the following:
   a. Johns Manville; Super Firetemp M.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide:
   a. 2-hour fire rating by an NRTL acceptable to authorities

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
   d. Thermal Ceramics; FireMaster Duct Wrap.
   e. 3M; Fire Barrier Wrap Products.
   f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

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

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. **Products**: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. **FSK Jacket Adhesive, and ASJ Adhesive**: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. **Products**: Subject to compliance with requirements, **provide one of the following**:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### 2.4 MASTICS

A. **Materials** shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. **Vapor-Barrier Mastic**: Water based; suitable for indoor use on below ambient services.

1. **Products**: Subject to compliance with requirements, provide one of the following:
   b. Vimasco Corporation; 749.

2. **Water-Vapor Permeance**: ASTM E 96/E 96M, Procedure B, **0.013 perm** at 43-mil dry film thickness.
3. **Service Temperature Range**: **Minus 20 to plus 180 deg F**.
4. **Solids Content**: ASTM D 1644, **58 percent** by volume and **70 percent** by weight.
5. **Color**: White.

C. **Breather Mastic**: Water based; suitable for indoor and outdoor use on above ambient services.

1. **Products**: Subject to compliance with requirements, provide one of the following:
b. Eagle Bridges - Marathon Industries; 550.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Products: Subject to compliance with requirements, provide one of the following:

   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:

1. **Products**: Subject to compliance with requirements, provide one of the following:
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.

   a. Sheet and roll stock ready for shop or field sizing
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: **3-mil-thick, heat-bonded polyethylene and kraft paper**.
   d. Moisture Barrier for Outdoor Applications: **3-mil-thick, heat-bonded polyethylene and kraft**.

2.9 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. **Products**: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. **Width**: **3 inches**.
3. **Thickness**: **6.5 mils**.
4. **Adhesion**: **90 ounces force/inch** in width.
5. **Elongation**: **2 percent**.
6. **Tensile Strength**: **40 lbf/inch** in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. **Products:** Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. **Width:** 2 inches.
3. **Thickness:** 3.7 mils.
4. **Adhesion:** 100 ounces force/inch in width.
5. **Elongation:** 5 percent.
6. **Tensile Strength:** 34 lbf/inch in width.

### 2.10 SECUREMENTS

A. Bands:

1. **Products:** Subject to compliance with requirements, provide one of the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. **Aluminum:** ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.
3. **Springs:** Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. **Capacitor-Discharge-Weld Pins:** Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.
   a. **Products:** Subject to compliance with requirements, provide one of the following:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; CD.
      3) Midwest Fasteners, Inc.; CD.
      4) Nelson Stud Welding; TPA, TPC, and TPS.

2. **Cupped-Head, Capacitor-Discharge-Weld Pins:** Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. **Products:** Subject to compliance with requirements, provide one of the following:
      1) AGM Industries, Inc.; CHP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. **Products:** Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

   b. **Baseplate:** Perforated, galvanized carbon-steel sheet, **0.030 inch** thick by **2 inches** square.
   c. **Spindle:** Copper- or zinc-coated, low-carbon steel fully annealed, **0.106-inch**-diameter shank, length to suit depth of insulation indicated.
   d. **Adhesive:** Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. **Products:** Subject to compliance with requirements, provide one of the following:

      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

   b. **Baseplate:** Perforated, nylon sheet, **0.030 inch** thick by **1-1/2 inches** in diameter.
   c. **Spindle:** Nylon, **0.106-inch-** diameter shank, length to suit depth of insulation indicated, up to **2-1/2 inches**.
   d. **Adhesive:** Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. **Products:** Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.

   b. **Baseplate:** Galvanized carbon-steel sheet, **0.030 inch** thick by **2 inches** square.
   c. **Spindle:** Copper- or zinc-coated, low-carbon steel, fully annealed, **0.106-inch**-diameter shank, length to suit depth of insulation indicated.
   d. **Adhesive-backed base with a peel-off protective cover.**
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at:
   a. 2 inch o.c.
   b. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.
C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

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

E. Insulation Installation at Floor Penetrations:

   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

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

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 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:
      a. 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:
   a. 50 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.
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.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

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

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers 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.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."
3.9 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. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.10 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. 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 for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 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.

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.

3.12 Insulation shall have an R value that meets the minimum requirements of the latest International Energy Conservation Code (IECC).

3.13 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. All supply and return ducts and plenums shall be insulated with not less than R-6 insulation.

B. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, outdoor-air and combustion-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

F. Concealed, rectangular, supply-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

G. Concealed, rectangular, return-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

H. Concealed, rectangular, outdoor-air and combustion-air duct insulation shall be one of the following:
   1. Flexible Elastomeric: 1-1/2 inch thick.
   2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation:
a. Fire-rated **blanket**; thickness as required to achieve 2-hour fire rating.
   1. Ductwork is to be wrapped with two layers of approved fire wrap that meets ASTM E-2336.

J. Concealed, supply-air plenum insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

K. Concealed, return-air plenum insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

L. Concealed, outdoor-air plenum insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

M. Exposed, round and flat-oval, supply-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

N. Exposed, round and flat-oval, return-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

O. Exposed, round and flat-oval, outdoor-air and combustion-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

P. Exposed, rectangular, supply-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

Q. Exposed, rectangular, return-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

R. Exposed, rectangular, outdoor-air and combustion-air duct insulation shall be **one of** the following:
   1. Flexible Elastomeric: **1-1/2 inch** thick.
   2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

S. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation:
   a. Fire-rated **blanket**; thickness as required to achieve 2-hour fire rating.

T. Exposed, supply-air plenum insulation shall be [**one of**] the following:
1. Flexible Elastomeric: **1-1/2 inch** thick.
2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

U. Exposed, return-air plenum insulation shall be **one of** the following:

1. Flexible Elastomeric: **1-1/2 inch** thick.
2. Mineral-Fiber Blanket: **2 inches** thick and **0.75-lb/cu. ft.** nominal density.

END OF SECTION 230713
SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Condensate drain piping.
   2. Chilled-water piping.
   3. Canal-water piping.
   4. Heating hot-water piping.
   5. Refrigerant suction and hot-gas piping.

1.3 DEFINITIONS:

A. Refer to Section 230500 “Common Work Results for HVAC”.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

   B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
      1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
      2. Detail attachment and covering of heat tracing inside insulation.
      3. Detail insulation application at pipe expansion joints for each type of insulation.
      4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
      5. Detail removable insulation at piping specialties.
      6. Detail application of field-applied jackets.
      7. Detail application at linkages of control devices.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

   B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.8 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.9 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Insulation for below-ambient service requires a vapor-barrier.
C. Products shall not contain asbestos, lead, mercury, or mercury compounds.

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

E. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

F. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

G. Calcium Silicate:
   1. Products: Subject to compliance with requirements, provide the following:
      a. Industrial Insulation Group (IIG); Thermo-12 Gold.
   2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

H. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553,
   1. Type II and ASTM C 1290, Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

   2. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

J. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Johns Manville; Micro-Lok.
      b. Knauf Insulation; 1000-Degree Pipe Insulation.
      c. Manson Insulation Inc.; Alley-K.
      d. Owens Corning; Fiberglas Pipe Insulation.
e. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A:
1) with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied:
1. ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.

L. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.2 INSULATING CEMENTS

1. Products: Subject to compliance with requirements, provide the following:
   a. Ramco Insulation, Inc.; Super-Stik.

1. Products: Subject to compliance with requirements, provide the following:
   a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

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

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 290.
   d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).


1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone.
   d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, \textbf{0.013 perm} at \textbf{43-mil} dry film thickness.
3. Service Temperature Range: \textbf{Minus 20 to plus 180 deg F}.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 570.

2. Water-Vapor Permeance: ASTM F 1249, \textbf{0.05 perm} at \textbf{30-mil} dry film thickness.
3. Service Temperature Range: \textbf{Minus 50 to plus 220 deg F}.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 550.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, \textbf{1.8 perms} at \textbf{0.0625-inch} dry film thickness.
3. Service Temperature Range: \textbf{Minus 20 to plus 180 deg F}.
4. Solids Content: 60 percent by volume and 66 percent by weight.

2.5 SEALANTS

A. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 40 to plus 250 deg F**.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. **ASJ-SSL**: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Johns Manville; Zeston.
   c. Proto Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system:
   a. White
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:
1. Products: Subject to compliance with requirements, provide one of the following:
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.

   a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications:
      1) 1-mil-thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications:
      1) 3-mil-thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Compac Corporation; 104 and 105.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.9 SECUREMENTS

A. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

E. Install multiple layers of insulation with longitudinal and end seams staggered.
F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

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

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.

3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

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

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

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

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

3.9 FIELD-APPLIED JACKET INSTALLATION
A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

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

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

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

3.11 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.

3.12 Insulation shall have a k value that meets the minimum requirements of the latest International Energy Conservation Code (IECC).

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric:
      1) 1/2 inch thick
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I:
      1) 1/2 inch thick

B. Chilled Water, 40 Deg F and below:

1. NPS 1-1/2 inch and Smaller: Insulation shall be the following:
   a. Flexible Elastomeric:
      1) 1-1/2 inch thick.

2. NPS 2 inch and Larger: Insulation shall be the following:
   a. Flexible Elastomeric:
      1) 1-1/2 inch thick.

3. Insulation for runouts not exceeding 48 inches in length for connection to equipment shall be the following:

   a. Flexible Elastomeric: 1 inch thick.

C. Chilled Water, above 40 Deg F:

1. NPS 1-1/2 inch and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric:
      1) 1-1/2 inch thick.
   b. Mineral-Fiber, Preformed Pipe, Type I:
      1) 1-1/2 inches thick.
2. **NPS 2 inch** and Larger: Insulation shall be one of the following:
   a. Flexible Elastomeric:
      1) 1-1/2 inch thick.
   b. Mineral-Fiber, Preformed Pipe, Type I:
      1) 1-1/2 inches thick.

3. Insulation runouts not exceeding **48 inches** in length for connection to equipment shall be one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick

4. Condenser-water supply and return piping located indoors and operating in range of 55 to 105 deg F (13 to 41 deg C) is not always insulated. If condenser-water system operates as part of a water-side economizer cycle or if Project requires condensation control, piping should be insulated.

**D. Canal-Water Supply and Return:**

1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Mineral-Fiber, Preformed Pipe, Type I:
      1) 1 inch thick

**E. Heating-Hot-Water Supply and Return, 200 Deg F and Below:**

1. **NPS 1 1/2** and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I:
      1) 1-1/2 inch thick

2. Greater than **NPS 1-1/2 inch**: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I or Pipe and Tank Insulation:
      1) 2 inches thick

3. Insulation for runouts not exceeding **48 inches** in length for connection to equipment shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

**F. Refrigerant Suction and Hot-Gas Piping:**

1. All Pipe Sizes: Insulation shall be **one of** the following:
   a. Flexible Elastomeric: 1 inch thick.

**G. Refrigerant Suction and Hot-Gas Flexible Tubing:**

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch thick.

**3.14 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:
   1. None.

D. Piping, Exposed:
   1. PVC:
      a. White: 30 mils thick.

END OF SECTION 230719
SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for the following HVAC&R systems, assemblies, and equipment:

1. Energy supply systems, including:
   a. gas supply

2. Heat generation systems, including:
   a. hot-water boilers
   b. auxiliary equipment

3. Cooling generation systems, including:
   a. canal-water systems
   b. direct-expansion systems

4. Distribution systems, including:
   a. air distribution (heating and cooling) systems
   b. hot-water distribution systems
   c. glycol distribution systems
   d. chilled-water distribution systems
   e. exhaust systems
   f. air-handling units

5. Terminal and packaged units, including:
   a. variable-air-volume (VAV) boxes
   b. unit heaters
   c. fan-coil units
   d. finned-tube radiation
   e. packaged units

6. Controls and instrumentation, including:
   a. Building automation system (BAS)

7. Systems testing and balancing verification, including:
   a. heating-water piping systems
   b. canal-water piping systems
   c. domestic hot-water circulating systems
   d. supply-air systems
   e. return-air systems
   f. exhaust-air systems

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.
1.3 DEFINITIONS

A. BAS: Building automation system.

B. DDC: Direct digital controls.


D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

E. TAB: Testing, adjusting, and balancing.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For BAS and HVAC&R Testing Technician.

B. Construction Checklists: See related Sections for technical requirements for the following construction checklists:
   1. Vibration and seismic controls for HVAC&R piping and equipment.
   2. Instrumentation and control for HVAC&R.
   3. Heating-water piping and accessories.
   4. Cooling-water piping and accessories.
   5. Refrigerant piping.
   6. Metal ducts and accessories.
   7. Fans.
   8. Particulate air filtration.
   9. Air-handling units.

1.5 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:
   1. Journey-level or equivalent skill level with knowledge of BAS, HVAC&R, electrical concepts, and building operations.
   2. Minimum three years’ experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. HVAC&R Testing Technician Qualifications: Technicians to perform HVAC&R construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:
   1. Journey-level or equivalent skill level. Vocational School four-year program graduate or an Associates degree in mechanical systems, air conditioning, or similar field. Degree
may be offset by three years’ experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC&R systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC&R equipment, assemblies, and systems.

2. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

3. One of the following:
   b. Associated Air Balance Council (AABC) Certified Test and Balance Technician.
   c. Owner retains the right to waive NEBB or AABC Certification.

C. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform HVAC&R commissioning work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
   a. Equipment/instrument identification number.
   b. Planned commissioning application or use.
   c. Manufacturer, make, model, and serial number.
   d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.

2. Test equipment and instrumentation shall meet the following criteria:
   a. Capable of testing and measuring performance within the specified acceptance criteria.
   b. Be calibrated at the manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
   c. Be maintained in good repair and operating condition throughout the duration of use on this Project.
   d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the commissioning process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
   a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
      1) Instrument or tool identification number.
      2) Equipment schedule designation of equipment for which the instrument or tool is required.
      3) Manufacturer, make, model, and serial number.
      4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
   b. Include a separate list of proprietary test instrumentation and tools in the operation and maintenance manuals.
c. HVAC&R proprietary test instrumentation and tools become the property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.

F. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.

G. Construction Checklists: Prepare and submit detailed construction checklists for HVAC&R systems, subsystems, equipment, and components.

1. Contributors to the development of construction checklists shall include, but are not limited to, the following:

   a. HVAC&R systems and equipment installers.
   b. TAB technicians.
   c. HVAC&R instrumentation and controls installers.

H. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.

2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.
3. Commissioning test procedures may direct that sensor values be altered with a signal
generator when design or simulating conditions and altering set points are impractical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system,
document the deficiency and report it to Owner. After deficiencies are resolved, reschedule
tests.

J. If seasonal testing is specified, complete appropriate initial performance tests and
documentation and schedule seasonal tests.

K. Coordinate schedule with, and perform the following activities at the direction of, Commissioning
Coordinator.

L. Comply with construction checklist requirements, including material verification, installation
checks, start-up, and performance tests requirements specified in Sections specifying HVAC
systems and equipment.

M. Provide technicians, instrumentation, tools, and equipment to complete and document the
following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Commissioning tests.

3.2 TAB COMMISSIONING TESTS

A. TAB Verification:

1. Prerequisites: Completion of "Examination" Article requirements and correction of
deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for
HVAC."
2. Completion of "Preparation" Article requirements for preparation of a TAB plan that
includes strategies and step-by-step procedures, and system-readiness checks and
reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
3. Scope: HVAC&R air systems and hydronic piping systems.
4. Purpose: Differential flow relationships intended to maintain air pressurization differentials
between the various areas of Project.
5. Conditions of the Test:

a. Commissioning Test Demonstration Sampling Rate: As specified in "Inspections"
Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
b. Systems operating in full heating mode with minimum outside-air volume.
c. Systems operating in full cooling mode with minimum outside-air volume.
d. For measurements at air-handling units with economizer controls; systems
operating in economizer mode with 100 percent outside air.

6. Acceptance Criteria:

a. Under all conditions, rechecked measurements comply with "Inspections" Article in
Section 230593 "Testing, Adjusting, and Balancing for HVAC."
b. Additionally, no rechecked measurement shall differ from measurements
documented in the final report by more than two times the tolerances allowed.
c. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.3 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 in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls." 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] [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 hot-water 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 refrigerant compressors and condensers. 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.

3.4 HEATING CONTROL SYSTEM COMMISSIONING TESTS

A. Heating-Water Supply Temperature Control:

1. Prerequisites: Installation verification of the following:
a. Startup of boiler.
b. Startup of heating-water pump(s).
c. TAB of heating-water flow and pressure.
d. Input Device: Heating-water supply temperature.
e. Output Device: Control valve.
f. Display the following at the operator's workstation:

1) Heating-water supply temperature.
2) Heating-water supply temperature set point.
3) Control-valve position.

2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at input device.
4. Conditions of the Test:

a. Minimum heating-water flow.
b. Midrange Heating-Water Flow: 50 to 60 percent of maximum.
c. Maximum heating-water flow.

5. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus 2.0 \( \text{deg F} \) (1.1 \( \text{deg C} \)) of set point.

B. Heating-Water Supply Temperature Reset:

1. Prerequisites: Installation verification of the following:

a. Startup of boiler.
b. Startup of heating-water pump(s).
c. TAB of heating-water flow and pressure.
d. Input Device: Heating-water supply temperature.
e. Input Device: Outdoor-air temperature; outdoor-air sensor.
f. Output Device: Control valve.
g. Display the following at the operator's workstation:

1) Outdoor-air temperature.
2) Heating-water supply temperature.
3) Heating-water supply temperature set point.
4) Control-valve position.

3.5 TERMINAL UNIT EQUIPMENT COMMISSIONING TESTS

A. Variable-Air-Volume Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following:

a. Occupancy Input Device: Occupancy sensor.
b. Occupancy Output Device: DDC system binary output.
c. Room Temperature Input Device: Room sensor.
d. Room Temperature Output Device: Electronic damper actuators and control-valve operators.
e. Display the following at the operator's workstation:

1) Room/area served.
2) Room occupied/unoccupied.
3) Room temperature indication.
4) Room temperature set point.
5) Room temperature set point, occupied.
6) Room temperature set point, unoccupied.
7) Air-damper position as percentage open.
8) Control-valve position as percentage open.

2. Acceptance Criteria:
   a. Temperature Control - Occupied:
      1) Control system status changes from "occupied" to "unoccupied" after the specified time.
      2) Room temperature is stable at occupied set point plus or minus 1.0 deg F (0.6 deg C) within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F (1.1 deg C) during transition.
   b. Temperature Control - Unoccupied:
      1) Control system status changes from "unoccupied" to "occupied" immediately.
      2) Room temperature is stable at unoccupied set point plus or minus 1.0 deg F (0.6 deg C) within 30 minutes of occupancy.

END OF SECTION 230800
23 0900

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Building Management and Control system (BMCS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only.

B. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

C. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s) and will be provided with Administration Passwords and copies of Stations.

D. System Provider:

1. Controls system provider for this project is Shall be certified with the Niagara N4.6 system and is responsible for the control work described herein, including material, labor, hardware, software, warranty, etc. including cost of system, design, programming, software setup and installation including wire and conduit (See Part 3 Execution of the Specification), checkout, test and demonstration. All control wiring shall be in metal conduit and shall be by the Project Electrical contractor.

E. All equipment and work performed with the BMCS shall comply to and seamlessly integrate with the graphical interface as installed by the primary control contractor.

1.2 SYSTEM DESCRIPTION

A. The New Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk communication protocols. Temperature Control System products shall be manufactured by Honeywell and shall be an extension of the existing Honeywell N4 WEBs Control System. All Spyder controllers provided must be Lon Controllers. Bacnet Spyders shall not be allowed.

B. The Building Management and Control System (BMCS) shall be comprised of Network Area Controller or Controllers (BMS) within the facility. The BMS shall connect to the owner’s local or wide area network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each BMS shall communicate to LonMark/LonTalk (IDC) controllers and other open protocol systems/devices provided under this Specification.

C. The Building Management and Control System (BMCS) as provided in this Specification shall be based on the Niagara N4 Framework minimum 4.6 revision.
1.3 SUBMITTAL

A. Four copies of shop drawings of the components and devices for the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions for all controllers, valves, dampers, sensors, routers, etc. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings. A complete written Sequence of Operation shall also be included with the submittal package. Specification contractors supplying products and systems, as part of their packages shall provide catalog data sheets, wiring diagrams and point lists for proper coordination of work.

B. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.

C. Submittal shall also include a complete point list of all points to be connected to the TCS and BMCS.

D. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or Owner.

E. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Four copies of the ‘as-built’ drawings shall be provided in addition to the documents on compact disk or USB flash drive. All as built drawings shall also be installed into the BMCS server in a dedicated directory.

1.4 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMCS</td>
<td>Building Management and Control System</td>
</tr>
<tr>
<td>TCS</td>
<td>Temperature Control System</td>
</tr>
<tr>
<td>BMS</td>
<td>Building Management Server</td>
</tr>
<tr>
<td>NAC</td>
<td>Network Area Controller</td>
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<tr>
<td>IDC</td>
<td>Interoperable Digital Controller</td>
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<tr>
<td>IBC</td>
<td>Interoperable BACnet Controller</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>WBI</td>
<td>Web Browser Interface</td>
</tr>
<tr>
<td>PMI</td>
<td>Power Measurement Interface</td>
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<tr>
<td>DDC</td>
<td>Direct Digital Controls</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>WAN</td>
<td>Wide Area Network</td>
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<tr>
<td>OOT</td>
<td>Object Oriented Technology</td>
</tr>
<tr>
<td>PICS</td>
<td>Product Interoperability Compliance Statement</td>
</tr>
</tbody>
</table>
1.5 DIVISION OF WORK

A. The specified contractors shall be responsible for all controllers (NAC, IDC), control devices, control panels, controller programming, controller programming software, controller input/output and power wiring and controller network wiring.

B. The specified contractor shall be responsible for the Network Area Controller(s) (BMS), software and programming of the BMS, graphical user interface software (GUI), development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, LonWorks network management and connection of the BMS to the local or wide area network.

C. Provide support for the Balancing Contractor.

D. Interface and work with Commissioning Agent (CxA)

1.6 AGENCY AND CODE APPROVALS

A. All products of the TCS and BMCS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided with the submittal package. Systems or products not currently offering the following approvals are not acceptable.

1. UL-916; Energy Management Systems
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 “signal Equipment”
3. CE
4. FCC, Part 15, Subpart J, Class A Computing Devices

1.7 SOFTWARE LICENSE AGREEMENT

A. The Owner shall agree to the manufacturer’s standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer’s license agreement, but shall protect manufacturer’s rights to disclosure of trade secrets contained within such software.

B. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the BMS, BMCS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner. The owner shall determine which organizations to be named in the SI organization ID (“orgid”) of all software licenses. Owner shall be free to direct the modification of the “orgid” in any software license, regardless of supplier.

1.8 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.


1.9 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 completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.

6. Test and inspection reports and certificates.

7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

1.10 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.11 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

PART 2 - MATERIALS

2.1 GENERAL
A. The Temperature Control System (TCS) and Building Management Control System (BMCS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system (Server provided by Customer), graphical user interface software, network devices, valves, dampers, sensors, and other devices as specified herein.

B. The installed system shall provide secure password access to all features, functions and data contained in the overall BMCS.

2.2 PRE-APPROVED INSTALLERS

A. Curtis Electric
B. Harris Controls
C. Atkinson Electronics

2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, LonWorks technology, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied Supervisor software with a 5-year Software Maintenance Agreement (SMA) shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE™ Standard 135-2001, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file and a resource file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP,) and/or RS-485 (BACnet MSTP) as specified.

C. All components and controllers supplied under this Specification shall be true “peer-to-peer” communicating devices. Components or controllers requiring “polling” by a host to pass data shall not be acceptable.

D. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer’s internal Intranet network. Systems employing a “flat” single tiered architecture shall not be acceptable.

1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.4 NETWORKS

A. The Local Area Network (LAN) shall be a 100 Megabits/sec or greater Ethernet network supporting Lon, BACnet, Java, XML, HTTP, and SOAP for maximum flexibility for integration of building data with enterprise information systems.

B. Local area network minimum physical and media access requirements:
   1. Ethernet; IEEE standard 802.3
   2. Cable; 100 Base-T, UTP-8 wire, category 5E or greater.
   3. Minimum throughput; 100 Mbps.

C. Echelon (LonWorks) Network shall be FTT10 with Honeywell E-Bus cable or CAT-5E equivalent

2.5 NETWORK ACCESS

A. Remote Access.
   1. For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.6 Building Management System

A. The contractor shall supply all control panels using JACE and sub-controllers (OPEN JACE with embedded workbench programming tool, Communication Drivers, and a 5-year Software Maintenance Agreement (SMA)) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices provided.

B. The Building Manager Server (NIAGARA SUPERVISOR WITH 5 YEAR SMA) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices. It shall be capable of executing application control programs to provide:
   1. Calendar functions
   2. Scheduling
   3. Trending
   4. Alarm monitoring and routing
   5. Time synchronization
   6. Integration of LonWorks or BACnet controller data and Niagara-N4 controller data
   7. Network Management functions for all LonWorks or BACnet based devices

C. The BMS must provide the following hardware features as a minimum:
   1. Server provided by Customer

D. The BMS shall provide multiple user access to the system and support for ODBC or SQL.
E. The BMS shall support standard Web browser access via the Intranet/Internet.

F. Event Alarm Notification and actions
   1. The BMS shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   2. The BMS shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via wide-area network.
   3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      a. To alarm
      b. Return to normal
      c. To fault

G. Control equipment and network failures shall be treated as alarms and annunciated.

H. Alarms shall be annunciated in any of the following manners as defined by the user:
   1. Screen message text
   2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
      a. Day of week
      b. Time of day
      c. Recipient
   3. Pagers via paging services that initiate a page on receipt of email message
   4. Graphic with flashing alarm object(s)

I. The following shall be recorded by the BMS for each alarm (at a minimum):
   1. Time and date
   2. Location (building, floor, zone, office number, etc.)
   3. Equipment (air handler #, access way, etc.)
   4. Acknowledge time, date, and user who issued acknowledgement.
   5. Number of occurrences since last acknowledgement.

J. Alarm actions may be initiated by user defined programmable objects created for that purpose.

K. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

L. A log of all alarms shall be maintained by the BMS and/or a server (if configured in the system) and shall be available for review by the user.

M. Provide a “query” feature to allow review of specific alarms by user defined parameters.

N. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

O. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

2.7 DATA COLLECTION AND STORAGE

A. The BMS shall have the ability to collect data for any property of any object and store this data for future use.
B. The data collection shall be performed by log objects, resident in the BMS that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, the object shall be configured for time of day, day of week and the sample collection time.
3. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

C. All log data shall be stored in a relational database in the BMS and the data shall be accessed from a server (if the system is so configured) or a standard Web browser.

D. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

E. All log data shall be available to the user in the following data formats:

1. HTML
2. XML
3. Plain Text
4. Comma or tab separated values

F. The BMS shall have the ability to archive its log data.

1. Archive on time of day
2. Archive on user-defined number of data stores in the log (buffer size)
3. Archive when log has reached its user-defined capacity of data stores
4. Provide ability to clear logs once archived

G. Histories and Trending.

1. Histories shall include all Input and Output devices and their associated control points i.e. Setpoints.
2. Trending shall be able to be displayed in Dashboards, charts, or graphs.

2.8 AUDIT LOG

A. Provide and maintain an Audit Log that tracks all activities performed on the BMS. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the BMS), to another BMS on the network, or to a server. For each log entry, provide the following data:

1. Time and date
2. User ID
3. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

2.9 DATABASE BACKUP AND STORAGE
A. The BMS shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.

B. Copies of the current database and, at the most recently saved database shall be stored in the BMS. The age of the most recently saved database is dependent on the user-defined database save interval.

C. The BMS database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

D. A copy of the current database shall be sent to customer headquarters.

2.10 INTEROPERABLE DIGITAL CONTROLLER (IDC)

A. Controls shall be the latest Honeywell Niagara N4 microprocessor based Interoperable LonWorks Controllers (IDC) with add on I/O modules or using Unitary Controller architecture. Where possible, all Interoperable Digital Controllers shall bear the applicable LonMark™ interoperability logo on each product delivered.

B. HVAC control shall be accomplished using LonMark™ based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. Publicly available specifications for the Applications Programming Interface (API) must be provided for each LonWorks / LonMark controller defining the programming or setup of each device. The contractor shall provide all programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation.

C. The Specified contractor shall run the LonWorks or BACnet network trunk to the nearest Network Area Controller (NAC). Coordinate locations of the BMS to ensure that maximum network wiring distances, as specified by the LonWorks wiring guidelines, are not exceeded. A maximum of 126 devices may occupy any one LonWorks trunk and must be installed using the appropriate trunk termination device. All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.

D. The Network Area Controller (NAC) will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks or BACnet based devices.

E. The IDCs shall communicate with the BMS at a baud rate of not less than 78.8K baud. The IDC shall provide LED indication of communication and controller performance to the technician, without cover removal.

F. All IDCs shall be fully application programmable and shall at all times maintain their LONMARK certification, if so certified. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Provide 10% capacity spare points on all control points.

G. The Specified contractor supplying the IDC’s shall provide documentation for each device, with the following information at a minimum:
   1. Network Variable Inputs (nvi’s); name and type
   2. Network Variable Outputs (nvo’s); name and type
   3. Network configuration parameters (nci, nco); name and type
H. It is the responsibility of the Specified contractor to ensure that the proper Network Variable Inputs and Outputs (nvi and nvo) are provided in each IDC, as required by the point charts.

2.11 GRAPHICAL USER INTERFACE SOFTWARE

A. Operating System:

1. The GUI shall run on latest Microsoft Windows Operating System.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

C. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:

1. Graphics shall be Honeywell Platinum Quality. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL’s, and links to other graphic screens.
3. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
4. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
5. Commands to start and stop binary objects shall be done by Selecting selected object and selecting the appropriate command from the pop-up menu.
6. Adjustments to analog objects, such as set points, shall be done by Selecting the selected object and adjusting the value.
7. All graphics to be approved by CE and or Commissioning Agent (CxA)

D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:

1. Select points to be trended over a period of time and initiate the recording of values automatically.

E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
F. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators’ access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

G. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

H. Alarm Console

1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.

2. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2.12 SYSTEM PROGRAMMING

A. Programmer shall use the latest version of the Workbench or equivalent programming tool.

2.13 LonWorks NETWORK MANAGEMENT

A. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as “binding”. Systems requiring the use of third party LonWorks network management tools shall not be accepted.

B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

C. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.

D. These tools shall provide the ability to “learn” an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing
LonWorks devices and newly added devices are part of a single network management database.

E. The network management database shall be resident in the Network Area Controller (BMS), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system, shall not be accepted.

2.14 OTHER CONTROL SYSTEM HARDWARE

A. Space Temperature Wall Module. Wall Module shall be Honeywell TR Series.
   1. Wall module shall have a thermistor temperature sensor with operating range of 45 to 99 F with UL 916 listing designed for mounting on a standard electrical switch box.
   2. Space temperature sensors shall be accurate to plus or minus one-degree F.
   3. Where specified, space temperature sensors shall have a setpoint knob calibrated for warmer-cooler adjustments (option: calibrated to allow plus or minus adjustments to a software setpoint).
   4. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of −30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
   5. Standard space sensors shall be available in an off white enclosure for mounting on a standard electrical box.
   6. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
   7. Where a local display is specified, the sensor shall incorporate either an LED or LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
   8. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
   9. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
  10. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
  11. A pneumatic signal shall not be allowed for sensing temperature.

B. Control Valves: (Globe Type) Valves shall be Honeywell. Control valves shall be 2-way or 3-way pattern as shown constructed for tight shutoff and shall operate satisfactory against system pressures and differentials.
1. Two-position valves shall be ‘line’ size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings).

2. Two-way water valves shall have equal percentage flow characteristics and three-way valves shall have equal percentage flow characteristics straight through and linear flow through the bypass.

3. Provide valve position indicator on all valves. Leakage rate shall be no more than 0.05% of Cv.

4. Valves 1/2 inch through 1 1/2 inch shall be screwed pattern except where solder connections are specified for valves 1/2 or 3/4 inches.

5. Valve and cartridge replacement tool shall be configured for maintenance or replacement without draining the coil to prevent water spill; however, an integral isolation valve on the control valve outlet will also be acceptable.

6. Valves shall close off against 58 psi minimum.

7. Two-inch valves shall be “screwed” configuration and 2-1/2 inch and larger valves shall be “flanged” configuration and ANSI-rated to withstand the pressures and temperatures encountered.

8. Valves shall have stainless-steel stems and spring-loaded Teflon packaging with replaceable discs.

C. Control Valves: (Characterized Ball Valves) Valves shall be Honeywell. All control valves up to 2” shall be characterized ball valves. Control valves ½ to 2 inches shall be 2-way or 3-way forged brass screwed pattern as shown constructed for tight shutoff and shall operate satisfactory against system pressures and differentials.

1. Two-position valves shall be ‘line’ size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings).

2. Two-way water valves shall have equal percentage flow characteristics and three-way valves shall have equal percentage flow characteristics straight through and linear flow through the bypass.

3. Leakage rate shall be ANSI Class IV (no more than 0.01% of Cv).

4. Valves shall be rated for no less than 350 psig at no less than 250 degrees F.

5. Provide a removable handle to operate valves manually during actuator power loss or failure.

6. Two-way valves shall close off against 100 psi minimum, and three-way valves shall close off against 40 psi minimum.

7. Valves shall have stainless-steel or chemically nickel-plated brass stem and throttling port.

8. Valves shall be tagged with Cv rating and model number.

D. Butterfly Control Valves: Valves shall be Honeywell. Where specified butterfly control valves over 2” in size shall be cast iron body type for 2-way or 3-way applications specified constructed for tight shutoff and shall operate satisfactory against system pressures and differentials.

1. Valves shall have tapped lugs for standard flange connection, and designed for isolation and removal of downstream piping at full rated pressure.

2. Two-position valves shall be ‘line’ size.
3. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (except as may be noted on the drawings).
4. Valves shall be rated for bubble tight shutoff at no less than 150 psi.
5. Valve disc shall be aluminum bronze.
6. Valve stems shall be stainless steel, with inboard top and bottom bronze bearings, and an external corrosion resistant top bearing to absorb actuator side thrust.

D. Control Valves

1. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
2. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
3. Trim material shall be stainless steel for steam and high differential pressure applications.
4. Electric actuation should be provided on all terminal unit reheat applications.

E. Duct Mount, Pipe Mount and Outside Air Temperature Sensors: Temperature sensors with an accuracy of $\pm 0.3^\circ$ F. Temperature sensors shall be 20K ntc Honeywell.

1. Outside air sensors shall include an integral sun shield.
2. Duct sensors shall have sensor approximately in center of the duct, and shall have selectable lengths of 6, 12, and 18 inches.
3. Multipoint averaging element sensors shall be provided where specified and shall have a minimum of one foot of sensor length for each square foot of duct area (provide multiple sensors if necessary).
4. Pipe mount sensors shall have copper, or stainless steel separable wells.

F. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point shall be provided where specified. Current switches shall include an integral LED for indication of trip condition and a current level below trip set point.

G. Low Temperature Limit Switches. Limit switches shall be Honeywell. Safety low limit dual contact shall be manual reset twenty-foot limited fill type responsive to the coolest section of its length.

H. High Temperature Limit Switches. Limit and Safety switches shall be Honeywell. Safety high limit (fire stats) shall be manual reset type.

I. CO2 Sensors. CO2 sensors shall be compatible with Honeywell.
1. Carbon Dioxide sensors shall be 0-10 Vdc analog output type, with corrosion free gold-plated non-dispersive infrared sensing, designed for duct mounting.
2. Sensor shall incorporate internal diagnostics for power, sensor, analog and output checking, and automatic background calibration algorithm for reduced maintenance. Sensor range shall be 0-2000 PPM with +/- 30 PPM accuracy.

J. Humidity Sensors. Humidity sensors shall be Honeywell.
1. Duct and room sensors shall have a sensing range of 5% to 95%.
2. Duct sensors shall be provided with a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall have a compensated ambient temperature range of -40°F to 170°F.

K. Pressure Sensors
1. Air pressure measurements in the range of 0 to 10” water column will be accurate to +/- 1% using a solid-state sensing element.
2. Differential pressure measurements of liquids or gases shall be accurate to +/- 0.5% of range. The housing shall be Nema 4 rated.

L. Current and KW Sensors
1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.
2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

M. Flow Sensors
1. Provide an insertion turbine flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by Onicon or approved equal.

N. Dampers
1. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
2. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals and acetal or bronze bearings shall also be provided.
3. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.

4. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.

5. Control and smoke dampers shall be Ruskin, or approved equal.

6. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

O. Damper Actuators

1. Damper actuators shall be electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

P. Airflow Measuring Stations

1. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.

2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

3. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.

4. Flow stations shall be Ebtron or approved equal with Lontalk interface.

Q. Temperature Control Panels: A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.

R. NCP field devices and components shall be as scheduled on the drawings or required Contract Documents.

M. Field Devices

1. Analog Input Sensors:
   c. C77041 Series – Mixed Air Averaging Temperature Sensor 144”.
   d. C7041 Series – Water Temperature Sensor (must order well separately)
   e. 50001774-001 – Water Temperature Sensor Well
   f. H7625B2006 – Duct Humidity/Temperature Sensor & Cover 0-10Vdc
   g. C7232B1014 – Return Air CO2 Sensor 0-10Vdc
   h. C7041 Series – OA Temperature Sensor.
   i. P7640A Honeywell Building Static Pressure Transducer 0-10 Vdc (or equivalent)
   j. P7640B Honeywell Duct Static Pressure Transducer 0-10 Vdc (or equivalent)
   k. H7635C2015 – System outside air humidity/temp sensor 0-10 Vdc
   l. Photocell (2-stage Digital input)
   m. PWT Honeywell Water differential pressure sensor
   n. MLH300PSCDJ1237 – Honeywell Tank Pressure Sensor 4-20ma (or equivalent)
2. Digital Input Sensors:
   a. TDIAP521030 – Duct High/Low Limit Pressure Safety Switch (or equivalent)
   b. Adjustable Honeywell, MCSP-A .7-250A – Run Status
   c. Adjustable Honeywell, CSP-O-F10-001 1.5-250A – Run Status.
   e. Adjustable Functional Devices, Inc. R1BXGTA.75-150A – Run Status.
   f. RIBU1C – Field Relay for Bypass Input
   g. DH100ACDCLP – Duct smoke detector
   h. ST-3 – Duct smoke detector sampling tube
   i. L482A - Low Limit (or equivalent)

3. Digital Output Devices:
   a. RIBU1C – Remote Field Mounted Relay
   b. RH2B-UL-24VAC – Idec 24VAC Relay
   c. SH2B-05 – Relay Socket
   d. BND1000 - Din Rail
   e. MS8120B10XX – 2 Position Spring Return Damper Actuator 175 in-lb. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each damper controlled.) Provide damper actuator of equal or greater quality.
   f. MN6120A1002 – 2 Position Non-Spring Return Damper Actuator 175 in-lb. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each damper controlled.) Provide damper actuator of equal or greater quality.
   g. RIB2401D – Remote field mounted relay (DPDT)

4. Analog Output Devices:
   a. MS7520B2007 – Modulating Damper Motor – Spring Return (16VA) – 175 in-lb. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality.
   b. MN7220A2007 – Modulating Damper Motor – Non Spring Return (6VA) – 175 in-lb. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality.
   c. MN7234A2008 – Modulating Damper Motor – Non-Spring return – 300 in- lb. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality.
   d. VGF21LSxx – 2-Way globe valve. Provide Honeywell or equivalent. Size valve according to valve schedule.
   e. 3-Way globe valve. Provide Honeywell or equivalent. Size valve according to valve schedule.
   f. Q5024 - Globe Valve Linkage with non-spring return MN7534A10XX actuator
   g. ML7421A1032 – Globe valve actuator – non-spring return (12VA) or equivalent. (Model number specified is only a family part number recommendation.)
Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality.

h. VBN2X-CV-SD – 2-Way ball valve w/MS7505A2008 actuator (13 VA) or equivalent. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality.

i. VBN3X-CV-SD – 3-Way ball valve w/MS7505A2008 actuator (13VA).

j. Q5024 - Globe Valve Linkage with non-spring return MN7534A10XX actuator – Font valve actuator

k. ML7421A1032 – Font valve actuator – non-spring return (12VA) or equivalent. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.)

6. VAV Box & Fan Coil Controllers & Components:

a. Spyder or Equivalent – CFCU fan coil controller
b. Stryker or Equivalent for VAV boxes with damper actuator
c. C7041B Series – Duct temperature sensor with 6" probe.
d. TR21 Series – Space Temperature Sensor with Set point
e. TR100VA004 – 100VA Transformer or equivalent
f. ML7410F3006 - VAV Reheat valve actuator.
g. VBN2xxxA & VBN3xxxA – VAV box reheat valve (ball valve w/MVNA or L Actuator) or equivalent. (Model number specified is only a family part number recommendation. Determine model number/quantities and size actuators for each valve controlled.) Provide valve actuator of equal or greater quality. Honeywell 3-way ball valves do not have stainless steel trims.

h. 24VAC/100 VA transformer panel housing. Existing panel may be used.

7. **Variable Frequency Drive**

   a. ABB or equivalent

2.15 **ACCESSORIES**

A. Software:

1. Integrate with existing Niagara N4.6 Supervisor. Coordinate with owner.

   a. Graphic displays shall be of high quality, consistent with graphics found in other recent temples, on-line created via operator station graphics package, Honeywell Platinum Graphics.

   b. Graphics to be approved by Owner Representative or Commissioning Agent (CxA).

B. Un-interruptible Power Supply (UPS)

1. Provide a UPS feature for each AHU, Plant DDC panel, VAV transformers.

C. Remote Communications
1. JACE 8000 (N4 Titan Jace) connected to customer intranet. Network I.D. to be provided by customer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All work described in this section shall be performed by system integrators or contractors that have a successful history in the design and installation of integrated control systems. The installing office shall have a minimum of five years of integration experience and shall provide documentation in the submittal package verifying the company's experience.

B. Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

C. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

D. Drawings of the TCS and BMCS network are diagrammatic only and any apparatus not shown but required to make the system operative to the complete satisfaction of the Engineer shall be furnished and installed without additional cost.

E. Low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by this contractor in accordance with these specifications.

F. Equipment furnished by the HVAC Controls Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by this contractor.

G. Shop fabricate and assemble all control Panels. Mount and wire BMCS field devices for DDC systems. Make a complete installation. Such devices include, but are not limited to:

1. Direct Digital Control (DDC) of air and water temperature, static and differential pressure sensing and control, damper and valve actuation, variable volume box control, electric relays, switches, transformers, and any and all other devices needed to make a complete system

2. Furnish and install wire, conductors, cables, control devices, panels, conduit etc. required for complete installation of BMCS devices. Make terminations. Check all installation for wiring and termination integrity.

3. Provide control system related materials and installation related to HVAC controls.

   a. Provide new controls for all air handlers, exhaust fans, and HVAC mechanical systems related equipment, its Air Handling Systems, miscellaneous systems and Central Plant.

H. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.
3.2 WIRING

A. All electrical control wiring and low voltage wiring to the control panels, BMS, computers and network components shall be the responsibility of this contractor.

B. The electrical contractor (Div. 26) shall furnish all power wiring to electrical starters, motors & control panels.

C. All wiring shall be in accordance with the Project Electrical Specifications (Division 26), the National Electrical Code and any applicable local codes. All BMCS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 26). Non-conduit run wiring is not allowed unless approved before hand by Customer.

3.3 WARRANTY

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

B. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this contractor at no expense to the Owner.

C. All wire will be copper and meet the minimum wire size and insulation class listed below:

<table>
<thead>
<tr>
<th>Wire Class</th>
<th>Wire Size</th>
<th>Isolation Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>12 Gauge</td>
<td>600 Volt</td>
</tr>
<tr>
<td>Class One</td>
<td>14 Gauge Std.</td>
<td>600 Volt</td>
</tr>
<tr>
<td>Class Two</td>
<td>18 Gauge Std.</td>
<td>300 Volt</td>
</tr>
<tr>
<td>Class Three</td>
<td>18 Gauge Std.</td>
<td>300 Volt</td>
</tr>
<tr>
<td>Communications</td>
<td>Per Mfr.</td>
<td>Per Mfr.</td>
</tr>
</tbody>
</table>

D. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

E. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

F. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
G. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

H. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

I. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

J. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.

K. Only glass fiber is acceptable, no plastic.

L. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

3.4 WARRANTY ACCESS

A. The Owner shall grant to this contractor, reasonable access to the TCS and BMCS during the warranty period.

B. The owner shall allow the contractor to access the TCS and BMCS from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

3.5 SOFTWARE LICENSE

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

B. The owner, or his appointed agent, shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use within the BMS. Any and all required ID’s and passwords for access to any component or software program shall be provided to the owner.

3.6 ACCEPTANCE TESTING

A. The existing Supervisor Station including points, graphics, and histories shall be complete and installed before site work commences so as not to hold up work by the Commissioning Agent.

B. Upon completion of the installation, this contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.
C. This contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a Point-by-Point Log to validate 100% of the input and output points of the DDC system operation. Log to be shown to the Owner's Representative or Commissioning Agent.

D. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative or Commissioning Agent, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative or Commissioning Agent. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative or Commissioning Agent. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

F. This contractor shall have 30 days to complete or repair any issues or deficiencies found during the acceptance Testing. This contractor will be responsible for any additional costs including airfare, transportation, labor and other expenses incurred by Commissioning Agent (CxA) for final validation beyond the original schedule.

3.7 OPERATOR INSTRUCTION, TRAINING

A. Training:

1. Use specified O&M manuals, record documentation, computer-based training (CBT), and on-line help utility. CBT to be through use of CD's or other software developed specifically for training.

2. Provide following training:

   a. Initial 6-hour session cover following topics:

      1) Sequence of operation review.
      2) Sign on-sign off.
      3) Selection of displays and reports
      4) Commanding of points, keyboard and mouse mode.
      5) Use of dialog boxes and menus.
      6) Password assignment / modification.
      7) Password modification.
      8) Operator assignment / modification.
      9) Operator authority assignment / modification.

   b. Provide second 6-hour training session covering following topics:

      1) Modifying warning limits, alarm limits and start-stop times.
      2) System initialization.
      3) Trending and reporting.
      4) Complete use of Portable Operators Terminal functions.
      5) Troubleshooting of sensors (determining bad sensors).
      6) Modification of control set points.
      7) Points disable / enable.
      8) Use of diagnostics.
c. Provide additional 4-hour supervisor training session and include following:
   1) Software review of Sequence of Operation.
   2) Graphic creation.
   3) System Maintenance procedures.
   4) Review of initialization.

3.8 DATA CONTROL AND GRAPHIC SUMMARY

A. General:

1. List of hardware points for each DDC controller appears on Mechanical Drawings. Graphics showing these points, along with appropriate pseudo points (i.e. set points, etc.) shall be incorporated into operational graphics.
   a. Provide software graphics and programming required to accomplish detailed sequence of operations.

3.9 POST INSTALLATION – SYSTEM SETUP, INSTALLATION AND CHECKOUT

A. General – All work is the responsibility of the Controls subcontractor

B. On-Site Supervision – provide:

   1. Responsibility for the overall control system installation.
   2. Oversight supervision of the control hardware and wiring installation team.

C. Controls Contractor shall provide:

   1. Key personnel as required to meet the following on-site requirements:
      a. General project supervision of on-site control work
         1) Maintain regular contact with Balancing Contractor, and Facility Manager to ascertain ongoing project status.
         2) Provide installation information when requested.
         3) Provide, at minimum, on-site inspections at following intervals
            a) Beginning of installation phase (initial kick-off meeting with contractors)
            b) System checkout and commissioning.

   C. Participate with Test and Balance contractor to affect a complete and functional system. Provide material to make a full and complete report of work undertaken and final conditions obtained.

3.10 IDENTIFICATION

A. Identify all control wires with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.

B. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.
C. Junction box covers will be marked to indicate that they are a part of the BAS system.

D. All I/O field devices (except space sensors) that are not mounted within FIP’s shall be identified with name plates.

E. All I/O field devices inside FIP’s shall be labeled.

3.11 LOCATION

A. The location of sensors is per mechanical and architectural drawings.

B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.

C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.12 VALVES

A. All temperature control valves shall be of the pressure independent control type.

PART 4 - SEQUENCE OF OPERATION

4.1 VAV FAN SYSTEMS RTU-1, RTU-2, & RTU-5

A. These VAV fan systems each consist of a supply fan array driven by a VFDs, a relief fan array driven by a VFDs, a preheat coil, a cooling coil, an evaporative cooling section, filters & modulating opposed blade outdoor air, return air, and relief air dampers.

B. The supply fan shall be started from a local DDC controller.

C. The supply fan shall run during normal occupied mode and cycle to maintain minimum space temperature and minimum discharge air temperature during unoccupied. Perimeter spaces with radiant heating shall attempt to maintain minimum space temperature by opening the radiant heat valve before cycling on the supply fan.

D. Fan system operation in HAND or AUTO mode shall be subject to freezestat, building fire alarm, supply duct high static pressure, inlet high negative static pressure, and door interlock switches. In the AUTO mode the fan system shall also be subject to building optimal start-stop programs, and other conditions or logic pre-programmed into the DDC controllers.

E. The control system shall monitor the amp draw of all VFD’s for all fan systems (supply, exhaust, relief). Fan status of operation shall be determined by the amp draw. An alarm shall be generated if a fan is commanded on and fails to start.
F. A current monitoring switch shall be installed on each fan in each fan array system. These switches shall be wired in series and connected to the DDC controller in a way that if one of the fans in the fan array fail an alarm shall be sent to the controller.

G. If the fan system is shut-down, or fails to start due to abnormal conditions, a ‘Safeties Alarm’ shall be sent to the DDC system. When the fan is stopped under any condition, the outside air dampers and relief air dampers shall close and the relief fans shall stop. A manual reset, high limit pressure switch within the fan room sensing supply duct static pressure shall shut down the fan and alarm the DDC system if its setting is exceeded. A high negative pressure switch located at the fan inlet shall shut down the fan and alarm the DDC system if the coil leaving temperature below 40 degrees F is exceeded. Labeled and illuminated indication shall be provided inside the DDC panel to indicate to the maintenance personnel the nature of the malfunction.

H. The ATC contractor shall wire the air handler door interlock switch to prevent fan operation when the door is open.

I. The fan system shall perform an optimal start program that shall include building warm-up and building purge features. In the warm-up mode, all outside air and relief air dampers shall remain closed, the relief fan shall remain off, and the air handler shall open the pre-heat coil valve 100% to discharge as warm of air as possible into the building. In this mode, the air dampers on the VAV boxes shall be reversed from their normal operation to allow the dampers to close as the room they control begins to warm up. In the purge mode, the preheat coil and cooling coil valves shall remain closed, the outside air and relief air dampers shall open to 100%. In purge mode, the relief fan system shall operate as in the occupied mode.

J. OCCUPIED mode: A supply air temperature sensor and an outdoor air temperature sensor, acting through DDC controllers, shall modulate the pre-heating and cooling coil valves, outdoor air and return air dampers, and stage the evaporative cooling and bypass damper to maintain supply air temperature according to the following schedule:

<table>
<thead>
<tr>
<th>Primary Reset:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GREATEST VAV COOLING LOAD</td>
<td>SUPPLY AIR TEMPERATURE</td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>70°F</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>62°F</td>
<td></td>
</tr>
</tbody>
</table>

K. The pre-heat coil, cooling coil, outside air and return air dampers and evaporative cooling stages shall operate in sequence without overlap to maintain the supply air temperature.

L. The relief fan array shall operate whenever the building is in the occupied or purge mode.

M. The operating sequence for the outside and return air dampers shall be as follows: When a call for more outside air is received, the outside air dampers shall modulate open while the return air dampers remain at 100%. Once the outside air dampers are 100% open, the return air dampers shall begin to modulate closed. When a call for less outside air is received, the above sequence shall be reversed. The purpose is to keep the dampers open as much as
possible to minimize the pressure drop across the dampers to save fan energy and provide better controllability.

N. The heating coil or cooling coil valve shall open for either heating or cooling depending on the supply air setpoint temperature.

O. The cooling section consists of direct evaporative cooling with bypass damper and a cooling coil in cooling mode which uses water from the canal water ground loop to provide free ground cooling. The cooling system is an important energy saving feature of the air handler. To maximize its benefit the bypass damper shall always be full open except if the discharge air temperature is warmer than the set point when the evaporative cooling section is on.

P. Outside air is the first stage of cooling.

Q. The cooling coil valve shall modulate open in cooling mode to allow free ground cooling as the second stage of cooling. When free ground cooling is used, the outside air dampers of the air handler shall remain full open. If the ground loop is off the coil valve shall remain closed. If the ground loop is on, the coil vale shall modulate as required to maintain discharge air setpoint temperature.

R. The cooling valve shall remain closed for cooling or heating when the outside air temperature is below 65 degF (adj.) The heating valve shall also modulate open for preheat as the discharge temperature falls below the discharge air temperature set point.

S. If the cooling valve is 100% open and there is water in the evaporative sump, and the discharge air temperature is above set point, the evaporative cooling system shall operate as the third stage of cooling. The evaporative cooling system once enabled shall remain enabled for the remainder of the day. Do not cycle the evaporative cooling pump. The primary temperature control in this mode will be modulation of the evaporative cooling bypass dampers. If the supply air temperature has dropped 2degF (adj.) below setpoint, the free ground cooling coil shall begin to modulate closed. The outside air dampers are to remain 100% open whenever the evaporative cooling system is enabled. The fan shall run for an additional 30 minutes after going into unoccupied mode if the evaporative pump has been running with the outside air damper open to dry out the evaporative media. A high sump water level safety shall close the make-up water and send an alarm to the DDC system if water is detected in the overflow pipe.

T. The sump of the evaporative cooling section shall be drained and filled each day that it is used. The fill shall only occur if the outside air temperature is above 50 degF and the evaporative cooling is needed for the day. If the outside air temperature is below 38 degF (adj.), the sump shall be drained.

U. A humidity sensor shall be installed in the building return air section of the air handler to monitor building humidity levels.

V. The outside air dampers shall maintain a minimum position sufficient to meet the minimum scheduled CFM fresh-air requirements. If the VAV boxes in each room have modulated to maximum ventilation and the air-quality sensors located in each room detect CO2 levels in the space in excess of the CO2 set point (ppm), the minimum CFM set-point shall be adjusted up
to the maximum scheduled fresh-air requirements. Total outside air flow shall be reported to
the DDC system by a matrix element style Ebtron flow meter.

W. The minimum fresh-air set-point shall be maintained anytime the air handler is in the occupied
mode and no VAV boxes require additional ventilation.

X. A 0-5” w.c. Supply duct static pressure transmitter with its static tip located 2/3 of the way
down the supply duct and acting through a DDC controller shall modulate supply fan speed to
maintain the supply duct static pressure set point as described below.

Y. The supply duct static pressure set point shall be continually adjusted by the DDC controller
through a PID control loop to ensure that at least one of the VAV box dampers served by the
air handler is at least 85% open. The intent of this control loop is to ensure that the supply fan
VFD operates at the lowest possible speed to maintain air flow requirements on all VAV
boxes. The supply duct static pressure PID control loop shall adjust the discharge set point
between 0.2” and 1.0” w.c. (adjustable) as required by the VAV box dampers.

Z. An averaging style air temperature sensor, acting through a DDC controller, shall provide 45°F
discharge air temperature low limit control of the air handling system acting as a pre-
freezestat.

AA. The relief fan array shall be enabled when the building is in the occupied or purge modes.

BB. A –0.25 to 0.25”w.c. static pressure transmitter with an outside probe, must be a Dwyer A306,
and an interior probe located in an interior hallway in area served by the fan, acting through
the DDC system shall modulate the relief fan VFD’s to maintain 0.05”w.c.maximum building
static pressure. The building static pressure sensor and the relief dampers shall all be
connected to the same DDC controller as the air handler serving the space. The relief system
shall be in operation whenever the building is in the occupied mode and supply fan is running.
Whenever the relief fan is not in operation, the relief damper shall spring-return closed.

CC. A differential pressure sensor shall be installed across the relief dampers. As the lead relief
fan turns on and begins to modulate, the relief damper shall begin to modulate to maintain a
0.05” pressure drop across the damper. As the pressure across the relief damper begins to
drop, the damper shall modulate closed to maintain the 0.05” set point.

DD. A temperature sensor shall be installed approximately 2 feet from the inlet of the relief fan
system. In the unoccupied mode, if this temperature falls below 50 degrees F, the air handler
shall be enabled (with the relief fans off) to circulate air in the plenum to prevent freezing.

EE. Daily total runtimes shall be displayed on the air handler graphic page for each piece of air
handler equipment (supply fan, exhaust fan, relief fan, evaporative cooling pump, etc). The
daily runtime value shall be recorded for reporting purposes then reset at the end of each day.

FF. The DDC system shall also provide negative building pressure control for the space that it
serves. If the building static pressure begins to fall below the minimum building static pressure
set point of 0.01”w.c., the controller shall send a signal to the outside air dampers to open to
allow negative building pressure control.
GG. UNOCCUPIED mode: The lowest space temperature sensor served by the air handler, acting through a DDC controller, shall cycle the supply fan to maintain desired minimum space temperature. All perimeter zones have hot water radiation which should be used as the first stage of heat to maintain the unoccupied set point. The fan should be able to remain off during unoccupied hours and should be the last stage of heat used to maintain the unoccupied set point (except during morning warm-up). The outdoor air & relief air dampers shall remain closed and the pre-heat water coil valve shall open to 100%.

HH. The unit heaters, located in the piping chase, and furnished with the air handler shall operate whenever the space temperature falls below 55 degrees F. On a call for heating, the heating valve and the unit heater fan shall operate simultaneously. The unit heater fan shall not be controlled by an aqua-stat.

4.2 SINGLE ZONE VAV/ERV FAN SYSTEM AHU-3

A. This fan system consists of two independent cabinet sections. The first section consists of an energy recovery fresh air system with heat wheel, supply and exhaust fan array driven by VFD’s, and filters and modulating opposed blade outdoor air, return air, and relief air dampers. The second section consists of heating coil, cooling coil and evaporative cooling section.

B. The supply fan shall be started from a local DDC controller.

C. The supply fan shall run during normal occupied mode and cycle to maintain minimum space temperature and minimum discharge air temperature during unoccupied. Perimeter spaces with radiant heating shall attempt to maintain minimum space temperature by opening the radiant heat valve before cycling on the supply fan.

D. Fan system operation in HAND or AUTO mode shall be subject to freezestat, building fire alarm, supply duct high static pressure, inlet high negative static pressure, and door interlock switches. In the AUTO mode the fan system shall also be subject to building optimal start-stop programs, and other conditions or logic pre-programmed into the DDC controllers.

E. The control system shall monitor the amp draw of all VFD’s for all fan systems (supply, exhaust, relief). Fan status of operation shall be determined by the amp draw. An alarm shall be generated if a fan is commanded on and fails to start.

F. A current monitoring switch shall be installed on each fan in each fan array system. These switches shall be wired in series and connected to the DDC controller in a way that if one of the fans in the fan array fail an alarm shall be sent to the controller.

G. If the fan system is shut-down, or fails to start due to abnormal conditions, a ‘Safeties Alarm’ shall be sent to the DDC system. When the fan is stopped under any condition, the outside air dampers and relief air dampers shall close and the relief fans shall stop. A manual reset, high limit pressure switch within the fan room sensing supply duct static pressure shall shut down the fan and alarm the DDC system if its setting is exceeded. A high negative pressure switch located at the fan inlet shall shut down the fan and alarm the DDC system if its set point is exceeded. A manual reset averaging freezestat located
downstream of the heating/cooling coil shall shut down the fan, open the coil valve and alarm the DDC system if the coil leaving temperature below 40 degrees F is exceeded. Labeled and illuminated indication shall be provided inside the DDC panel to indicate to the maintenance personnel the nature of the malfunction.

H. The ATC contractor shall wire the air handler door interlock switch to prevent fan operation when the door is open.

I. The fan system shall perform an optimal start program that shall include building warm-up and building purge features. In the warm-up mode, all outside air and relief air dampers shall remain closed, the exhaust fan of the energy recovery system shall remain off, the exhaust fan shall remain off, and the air handler shall open the heating coil valve to maintain supply air setpoint temperature. In the purge mode, the preheat coil and cooling coil valves shall remain closed, the outside air and relief air dampers shall open to 100%, the exhaust fan of the energy recovery system shall start and the heat wheel shall remain off to allow the air handler to discharge the coolest possible temperature into the building. In purge mode, the relief fan system shall operate as in the occupied mode.

J. OCCUPIED mode: A supply air temperature sensor and an outdoor air temperature sensor, acting through DDC controllers, shall modulate the pre-heating and cooling coil valves, outdoor air and return air dampers, and stage the evaporative cooling and bypass damper to maintain supply air temperature according to the following schedule:

<table>
<thead>
<tr>
<th>ROOM COOLING LOAD</th>
<th>SUPPLY AIR TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>68°F (adj.)</td>
</tr>
<tr>
<td>100%</td>
<td>62°F</td>
</tr>
</tbody>
</table>

K. The pre-heat coil, cooling coil, outside air and return air dampers and evaporative cooling stages shall operate in sequence without overlap to maintain the supply air temperature.

L. The heat wheel for the energy recovery unit is designed to recover heat from the unit’s relief air and preheat the inlet outside air. The heat wheel shall be enabled whenever the air handler is occupied, the outside air dampers are open, and the air handler is in the preheat mode (requires heat). The heat wheel shall be disabled whenever the air handler is in warm-up mode or when no preheat is needed. The heat wheel shall not be used in cooling modes (bypass damper shall be 100% open). Frost control of the heat wheel will be by factory installed VFD controls.

M. Status of heat wheel operation shall be monitored by the control system. If the heat wheel fails to start an alarm shall be generated. The DDC controller shall monitor the VFD and report frost status to the front end.

N. The exhaust fan array shall operate whenever the building is in the occupied or purge mode.

O. The operating sequence for the outside and return air dampers shall be as follows: When a call for more outside air is received, the outside air dampers shall modulate open while the return air damper modulates closed. Once the outside air dampers are 100% open, the
return air dampers shall fully closed. When a call for less outside air is received, the above sequence shall be reversed.

P. The cooling section consists of direct evaporative cooling with bypass damper and a cooling coil which uses water from the canal ground loop to provide free ground cooling. The cooling system is an important energy saving feature of the air handler. To maximize its benefit the bypass damper shall always be full open except if the discharge air temperature is colder than the set point when the evaporative cooling section is on.

Q. Outside air is the first stage of cooling.

R. The cooling coil valve shall modulate open in cooling mode to allow free ground cooling as the second stage of cooling. When free ground cooling is used, but the evaporative cooling is off, the outside air dampers of the air handler shall maintain the minimum outside airflow. If the ground loop is off the coil valve shall remain closed.

S. The cooling valve shall remain closed for cooling when the outside air temperature is between 50 and 65 degF. As the discharge temperature falls below the discharge air temperature set point, the cooling valve shall close and the heating valve shall modulate open to maintain discharge air temperature.

T. If the cooling valve is 100% open and there is water in the evaporative sump, and the discharge air temperature is above set point, the evaporative cooling system shall operate as the third stage of cooling. The evaporative cooling system once enabled shall remain enabled for the remainder of the day. Do not cycle the evaporative cooling pump. The primary temperature control in this mode will be modulation of the evaporative cooling bypass dampers. The outside air dampers are to open to 100% whenever the evaporative cooling system is enabled. The fan shall run for an additional 30 minutes after going into unoccupied mode if the evaporative pump has been running with the outside air damper open to dry out the evaporative media. A high sump water level safety shall close the make-up water and send an alarm to the DDC system if water is detected in the overflow pipe.

U. The sump of the evaporative cooling section shall be drained and filled each day that it is used. The fill shall only occur if the outside air temperature is above 50 degF and the evaporative cooling is needed for the day. If the outside air temperature is below 35 degF, the sump shall be drained.

V. A humidity sensor shall be installed in the building return air section of the air handler to monitor building humidity levels.

W. The outside air dampers shall maintain a minimum position sufficient to meet the lower minimum scheduled CFM fresh-air requirements. If the supply fan has modulated to its maximum supply airflow and the air-quality sensors located in each room detect CO2 levels in the space in excess of the CO2 set point (ppm), the minimum outside airflow set-point shall be adjusted up to the maximum scheduled fresh-air requirements.
X. Airflow sensing shall be a matrix element Ebtron Gold or equivalent CFM sensor. Total airflow shall be reported to the DDC system. Flow meters shall be installed in the following locations:

1. Outside Airflow
2. Supply Airflow
3. Exhaust Airflow

Y. The low-end minimum fresh-air set-point shall be maintained anytime the air handler is in the occupied mode.

Z. Room space temperature sensing shall be from a wall-mounted temperature sensing element. A painted wooden block shall be installed behind the temperature sensor to provide thermal isolation from the masonry wall. A heavy duty thermostat guard shall be provided for the temperature sensor in the multi-purpose room.

AA. The DDC controller shall modulate the supply fan VFD between minimum and maximum design supply airflow and modulate the heating and cooling as required to maintain setpoint temperature. A PID loop shall determine the appropriate discharge air temperature to maintain setpoint. The temperature and airflow setpoints shall control similar to the VAV boxes.

BB. Initial space temperature set points shall be 70-degF (adj.) heating and 74-degF (adj.) cooling when the building is occupied. Unoccupied set point shall be 60-degF (adj.) heating with no cooling setpoint.

CC. An averaging style air temperature sensor, acting through a DDC controller, shall provide 45°F discharge air temperature low limit control of the air handling system acting as a pre-freezestat.

DD. The exhaust fan array shall be enabled when the building is in the occupied or purge modes. Exhaust airflow shall be monitored as noted above.

EE. When unoccupied, the exhaust damper shall be closed, the exhaust fans shall remain off and outside air damper closed.

FF. When occupied, the exhaust airflow shall match the outside airflow, minus an offset determined by the balancer in order to maintain a positive space. When occupied, the above dampers (exhaust & outside air) shall be open, and the exhaust fan shall control to maintain airflow offset. A differential pressure sensor shall be installed across the exhaust air damper. When the exhaust fan is running, the exhaust air damper shall modulate to maintain a differential pressure of 0.05” w.g. Whenever the air-handler is deactivated, the outside air and exhaust air dampers shall spring return closed.

GG. The heat wheel shall be enabled and the appropriate exhaust mode shall be selected whenever the outside air temperature is below 50° and the building is in the occupied mode.

HH. A temperature sensor shall be installed approximately 2 feet from the inlet of the exhaust fan system. In the unoccupied mode, if this temperature falls below 50 degrees F, the air handler shall be enabled (with the relief fans off) to circulate air in the plenum to prevent freezing.
II. Daily total runtimes shall be displayed on the air handler graphic page for each piece of air handler equipment (supply fan, exhaust fan, relief fan, heat wheel, evaporative cooling pump, etc). The daily runtime value shall be recorded for reporting purposes then reset at the end of each day.

JJ. The DDC system shall also provide negative building pressure control for the space that it serves. If the building static pressure begins to fall below the minimum building static pressure set point of 0.01"w.c., the controller shall send a signal to the outside air dampers to open to allow negative building pressure control.

KK. UNOCCUPIED mode: The air handler, acting through a DDC controller, shall cycle the supply fan to maintain desired minimum space temperature. All perimeter zones have hot water radiation which should be used as the first stage of heat to maintain the unoccupied set point. The fan should be able to remain off during unoccupied hours and should be the last stage of heat used to maintain the unoccupied set point (except during morning warm-up). The outdoor air & relief air dampers shall remain closed and the pre-heat water coil valve shall open to maintain setpoint temperature.

4.3 AIR FLOW METERS (EBTRON OR EQUIVALENT)

A. All outside air flow shall be monitored by a matrix element style Ebtron Gold flow meter or equivalent.

B. Ebtron meters shall be tied to the control system via Lontalk interface to monitor all available data.

4.4 FIRE ALARM FAN SHUT DOWN (All Fan Systems)

A. All heating, ventilating and air conditioning system supply fans shall automatically shut off when the building fire alarm system is energized. All fans to automatically start up again when fire alarm system is reset. Fire alarm system fan relays shall be "normally energized" and shall be installed by Division 26 at each fan system.

4.5 BUILDING HEATING AND COOLING LOOPS

A. There are three main building water loops in the building. One is the cooling canal loop which serves the air-handling unit cooling coils. One is the glycol preheat loop and serves the preheat coils in the air handlers. The other loop is the heating loop and serves the radiant heating panels and VAV reheat coils.

B. The Cooling Loop separates the cooling coils from the canal via heat exchangers HX-1A & HX-1B (50% capacity each for improved scouring effect at reduced flow.) The canal side is served by two primary/standby pumps (P-1 & P-2) sized at 100% capacity each (for improved redundancy.) The canal side is also equipped with three levels of filtration (Drum Filter at the canal; Basket Strainer, and a Cyclone Separator.) The cooling coil side is served by two primary/standby pumps (P-3 & P-4) sized at 100% for improved redundancy.
C. The Glycol Preheat Loop shall receive heat via HX-2A & HX-2B from the heating loop as described below. Both heat exchangers and the associated primary/standby pumps (P-7 & P-8) are sized for 100% for improved redundancy.

D. The heating loop shall receive heating from the two boilers B-1 & B-2 (sized at 60% each) and the associated primary/standby heating water pumps P-5 & P-6 (sized at 100% each.) water to water heat pump BHP-1 or the boiler B-1.

4.6 COOLING-LOOP/CANAL-LOOP CONTROL

A. The hydronic cooling system consists of two independent loops (Chilled Water / Canal.) The chilled water coils (located in the AHU’s) are separated from the canal water via two plate and frame heat exchangers (HX-1A & HX-1B).

B. Chilled Water System Enable: The chilled water system shall be enabled whenever the outside air temperature is above 55°F (adj), the building is occupied or is in purge mode and any air handler cannot make its discharge air setpoint (65°F) with the outside air dampers fully open, then the chilled water system shall be enabled (cooling mode). The local DDC controllers shall alternate the lead pump on a monthly basis. If a pump does not run when it is commanded to do so, the second pump shall start and an alarm shall be sent to the DDC system.

C. Once enabled, The Canal Side shall run as follows:

1. The BAS system shall monitor the canal water level height with an analog float level to determine if the cooling water in the canal is available and at a sufficient height. If canal water is available and building needs cooling the controller shall enable the drum filter motor, and the cleaning pump (located at the canal basin.) The BAS system shall monitor the status of these motors. When both motors are running the lead canal pump (P-1/P-2) shall be enabled. If either motor stops or the float contact opens, the chilled water pumps shall be disabled and an alarm shall be sent to the building operator. A low water level alarm shall provide early warning in the event that the canal level is nearing pump cut-off level.

2. A DDC controller shall monitor the canal water system flow. Upon initial start-up, both heat exchangers (HX-1A & HX-1B) control valves shall be open, and the canal pump shall control to the combined specified flow of both heat exchangers. Flow thru the canal side of the heat exchangers shall not drop below HX’s specified flow to ensure proper scouring of the heat exchangers. When only one heat exchanger is operating, the system shall control to the minimum flow of the cyclone filter F-1 (which slightly exceeds the specified flow of the heat exchanger.) The controller shall modulate the speed of the lead canal pump to maintain required flow.

3. If the chilled water supply side drops 3-degF (adj.) below setpoint, the lead heat exchanger shall remain open, and the lag heat exchanger control valves shall close. If the chilled water supply side continues to drop another 2-degF below setpoint, the chilled water system shall be disabled and the drum filter/pump shall be disabled. Once disabled, the lag HX shall remain disabled for 30-minutes (adj.) to prevent cycling.
4. Canal Water Temperature Monitoring: BAS system shall monitor the canal supply and return temperatures.

5. Filter F-1: The basis of design Puroflux PF61-040 cyclone filter is furnished with its own NEMA 4x control panel. The filter operates under its own controls with integral time controller. The ATC contractor shall provide all necessary points and contacts necessary to monitor the following points:

   a. Cycle Time: Frequency of purging (in 0.1 hour increments)

   b. Purging Time: Duration of purging (in seconds)

   c. Total cycles: Total number of cycles since last reset.

6. BS-1: This filter is a standard basket strainer. The ATC contractor shall furnish a blowdown valve that discharges to waste. The ATC contractor shall furnish and install the differential pressure monitor across the strainer. The blow down valve shall control as follows:

   a. Hourly: The strainer shall blow down every 24-hours (adj.)

   b. Differential Pressure: When the DP exceeds a value determined by the balancer, the strainer valve shall blow down.

   c. Duration: Shall be 60-seconds (adj.)

D. Once enabled, The Chilled Water Side shall run as follows:

1. The two primary/standby building chilled water pumps (P-3 & P-4) are sized for 100%. The pumps are controlled by VFD’s. The DDC system shall modulate the pump VFD speed to maintain a cooling water differential pressure set point of 10 PSI (adjustable). This set point shall be coordinated with the balancer to make sure the set point meets field conditions.

2. Provide supply and return temperature sensors in the cooling loop connected to the DDC system.

3. The controls contractor shall provide a pressure sensor for monitoring the cooling loop pressure (see plans for locations.) The sensor shall be hardwired back the DDC controller responsible for controlling the cooling water pump VFD speed. No indirect or software points will be acceptable. The pressure sensor shall be located near the end of the main building water loop in the furthest air handler as indicated by the engineer.
**4.7 GLYCOL PREHEAT LOOP CONTROL**

A. The main loop pumps P-7 and P-8 shall run as follows: The preheat pump shall run continuously when the building is occupied and the outside air temperature is below 50°F (preheat mode). Also, if the building is unoccupied and any fan system is operating to heat the building or if an air handler is operating in warm-up mode the lead pump shall be enabled (preheat mode). The local DDC controllers shall alternate the lead pump on a monthly basis. If a pump does not run when it is commanded to do so, the second pump shall start and an alarm shall be sent to the DDC system.

B. The two building preheat water pumps are controlled by VFD’s. The DDC system shall modulate the pump VFD speed to maintain a preheat water differential pressure set point of 10 PSI (adjustable). This set point shall be coordinated with the balancer to make sure the set point meets field conditions.

C. Provide supply and return temperature sensors in the preheat loop connected to the DDC system.

D. The controls contractor shall provide a pressure sensor for monitoring the preheat loop pressure. The sensor shall be hardwired back the DDC controller responsible for controlling the preheat water pump VFD speed. No indirect or software points will be acceptable. The pressure sensor shall be located near the end of the main building water loop in the furthest air handler as indicated by the engineer.

E. Status indication of pump operation will be from the analog current signal provided at the VFD for each pump. The control system will monitor the amps and provide pump status from the amp signal. The VFD status shall enable the VFD control loop. Loss of VFD status shall enable the lag pump. Verification of either pump status point shall enable the heating and cooling pumps as required to control the temperature of the loop.

F. Preheat mode for the loop shall be when the building is in the occupied mode and the outside air temperature is below 50°F (adj.) or when the building is in the unoccupied mode and the air handler is in the warm-up mode. In the glycol preheat mode, the heat exchangers HX-2A & HX-2B shall stage to maintain setpoint temperature. When one or
both of the heat exchangers is staged on, the glycol side 2-position valve shall fully open, and the hot water side valve shall modulate to maintain setpoint temperature.

4.8 HEATING LOOP CONTROL

A. The main loop pumps P-5 and P-6 (primary/standby) shall run as follows: The lead heating pump shall run continuously when the building is occupied and the outside air temperature is below 58°F (adjustable) or a zone served by the air handlers is calling for heat. Also, if the building is unoccupied and any zone served by the air handlers is calling for heat, if an air handler is operating in warm-up mode, or the outside air temperature is below 30°F the lead pump shall be enabled. The local DDC controllers shall alternate the lead pump on a monthly basis. If a pump does not run when it is commanded to do so, the second pump shall start and an alarm shall be sent to the DDC system. The pumps shall run anytime B-1 or B-2 are enabled.

B. The two building heating water pumps are controlled by VFD's. The DDC system shall modulate the pump VFD speed to maintain a cooling water differential pressure set point of 10 PSI (adjustable.) This setpoint shall be coordinated with the balancer to make sure the setpoint meets field conditions.

1. A pressure sensor for monitoring the heating loop pressure will be provided. The sensor shall be hardwired back the DDC controller responsible for controlling the heating water pump VFD speed. No indirect or software points will be acceptable. The pressure sensor shall be located near the end of the main building water loop as indicated by the engineer.

C. Provide supply and return temperature sensors in the heating loop connected to the DDC system.

D. Status indication of pump operation will be from the analog current signal provided at the VFD for each pump. The control system will monitor the amps and provide pump status from the amp signal. The VFD status shall enable the VFD control loop. Loss of VFD status shall enable the lag pump. Verification of either status point shall enable the water to water heat pump, boiler, and pumps as required to control the temperature of the loop.

E. The basis of design boiler is furnished with a hydronic control system. A Lontalk interface (coordinate with boiler manufacturer) from the control system to the boiler will be provided. The controls shall monitor the operation of B-1 & B-2 through the interface but control of the boiler will be through physical wiring connections. Software enable and control is not permitted.

F. The boilers shall be enabled anytime the heating loop is enabled, and to maintain setpoint temperature. The setpoint temperature shall reset based on outdoor air temperature:

<table>
<thead>
<tr>
<th>Outdoor Air Temperature</th>
<th>Hydronic Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 45°F</td>
<td>130°F (adjustable)</td>
</tr>
<tr>
<td>Above 45°F</td>
<td>110°F (adjustable)</td>
</tr>
</tbody>
</table>
4.9  **EMERGENCY SHUTDOWN SWITCHES (Boilers & Water Heaters)**

A. A remote mushroom type, single acting, manually reset, shutdown switch shall be located just inside each boiler room door and marked for easy identification. A pilot light shall illuminate whenever the push button is pressed. If there is more than one door to the boiler room, there should be a switch located at each door.

B. The emergency shutdown switch(es) when activated must disconnect all power to the boiler burner and all hot water heater controls. A visual alarm indicator of a different color than the building fire alarm indicators shall be activated when the boilers are shutdown.

4.10  **VAV BOX CONTROL**

A. In general, VAV boxes will have reheat coils with perimeter radiant heaters. Exact configurations are shown on the drawings.

B. Room space temperature sensing shall be from wall-mounted temperature sensing elements with adjustable set points (Slide-stats). Room CO2 sensing shall be by a separate wall mounted CO2 sensor (located in the breathing zone). The CO2 sensor shall be of self-calibrating type.

C. The space sensors located in the hallways and toilet rooms shall not have temperature adjustment capability (Slide-stat) or CO2 sensor monitoring. (Collaborative areas are not hallways).

D. A duct style temperature sensor shall be installed at each VAV box air discharge.

E. Each VAV box shall be connected to the motion sensor provided by division 26 for lighting control. VAV boxes located in the hallways and commons areas shall not have a motion sensor. The occupancy sensor through the DDC system and a maintained time delay relay shall return the VAV box back to a vacant state when no motion is sensed for 30 minutes (adjustable).

F. All VAV boxes shall be programmed to occupied mode each morning the building is scheduled for occupancy until 8:00 am (adjustable) to allow the building to warm-up or purge as required. After 8:00 am, the motion sensors in each room shall determine occupancy or vacancy of the VAV box.

G. A VAV box-mounted DDC controller shall be provided for control and operation of each VAV box perimeter radiant heater and reheat coil. The controller shall modulate the VAV box primary air damper between minimum ventilation position and maximum designed airflow and modulate the reheat coil valve or the perimeter radiant heater valve in sequence to maintain the desired space temperature. Heating and cooling set points shall be individually adjustable from the man-machine interface device (Host computer) or the District offices.

H. Initial space temperature set points shall be 70° heating and 74° cooling when the building is occupied. Unoccupied set point shall be 60° heating with no cooling set point. The initial slide stat adjustment range shall be set to 1°.
I. Unless scheduled otherwise, all reheat VAV boxes shall maintain the minimum CFM set point for heating.

J. The primary air damper of the VAV box shall be capable of reversing operation as required for building warm-up or central plant heat applications.

K. All classrooms, media center, and collaborative areas will utilize demand controlled ventilation to determine their minimum CFM set point. If the CO2 level in the space falls below the CO2 set point (ppm), the minimum CFM set point can be adjusted down to zero. As the CO2 level begins to rise above the CO2 set point (ppm), the minimum CFM set point of the VAV box will be adjusted up to the maximum scheduled CFM to satisfy the CO2 levels. If the VAV box is operating at maximum CFM and the CO2 level is not satisfied, a signal shall be sent from the VAV box to the air handler to increase the outside air ratio allowing more fresh air into the space.

L. If the occupancy sensor determines that the space is vacant, the VAV box minimum ventilation will be set to zero. In the vacant mode, the space temperature set point shall remain in effect and the temperature control will override the vacancy mode to maintain the space temperature set point as required.

M. A spreadsheet style quickview graphic shall be provided to show VAV box operational status. The following points shall be displayed for each VAV box: Occupancy, Space Temp, Space Temp set point, Damper position, HW valve position, %Load, CO2 level, CFM air flow, CFM set point, Discharge Temperature, BTU load of the space, BTU total consumption for the day shall be displayed.

N. Each VAV box DDC controller shall have a 24-volt power connection with all 24-volt control wiring by the ATC contractor. Transformers for the VAV controllers shall be centrally located in the respective air handler equipment room.

O. Each VAV interface controller shall be loaded to a maximum capacity of 90%. 10% spare space shall be provided to allow for expansion and additional programming.

4.11 LARGE VAV BOXES

A. The large VAV boxes will serve Multi-Purpose, Platform and Commons areas. Platform and Commons areas will also have perimeter radiant heat. Exact configurations are shown on the drawings.

B. Room space temperature sensing shall be from a wall-mounted temperature sensing element. A painted wooden block shall be installed behind the temperature sensor to provide thermal isolation from the masonry wall. A heavy duty thermostat guard shall be provided for the temperature sensor in the multi-purpose room.

C. Air flow sensing shall be by a matrix element Ebtron silver or equivalent CFM sensor. A duct style temperature sensor shall be installed at the discharge of the VAV box.

D. The DDC controller shall modulate the VAV box opposed blade primary air damper between minimum ventilation position and maximum designed airflow and modulate the reheat coil and stage the perimeter radiation coils in sequence to maintain the desired
space temperature. Heating and cooling set points shall be individually adjustable from the man-machine interface device.

E. VAV boxes with reheat coils will also require increased CFM flow above the box minimum CFM set point when the reheat coil is required for space heat (see schedule).

F. Initial space temperature set points shall be 70° heating and 74° cooling when the building is occupied. Unoccupied set point shall be 60° heating with no cooling set point.

4.12 KITCHEN FAN COIL UNIT

A. The kitchen fan coil unit shall run anytime the kitchen is occupied and there is a call for heating or cooling as follows:

1. Occupied Mode: The unit shall maintain
   a. A 75-degF (adj.) cooling setpoint.
   b. A 70-degF (adj.) heating setpoint.

2. Unoccupied Mode: The unit shall maintain
   a. A 85-degF (adj.) cooling setpoint.
   b. A 85-degF (adj.) heating setpoint.

B. Zone Setpoint Adjust: The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

C. Zone Unoccupied Override: A times local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

D. Smoke Detection: The unit shall shut down and generate an alarm upon receiving a smoke detector status.

E. Cooling Valve: The controller shall measure the zone temperature and modulate the cooling coil valve to maintain its cooling setpoint.

F. Heating Valve: The controller shall measure the zone temperature and modulate the heating coil valve to maintain its cooling setpoint.

G. Filter Differential Pressure Monitor: The controller shall monitor the differential pressure across the filter. Alarms shall be provided when pressure exceeds a user definable limit (adj.)

H. Discharge Air Temperature: The controller shall monitor the discharge air temperature.

I. Fan Status: The controller shall monitor the fan status. Alarms shall be provided when the fan is commanded on, but the status is off.
4.13 AREA SECURITY TEMPERATURE ALARMS

A. Temperature sensors located in an area served by each fan system shall continuously monitor the space temperature and alarm the building Host computer anytime the space temperature drops below or rises above preset set points.

B. Upon receiving an alarm the Host computer at the school and at the District Offices shall indicate which area(s) of the building are in alarm through a graphic floor plan display of the building(s). Current space temperatures shall also be displayed at the Host computer.

4.14 DOMESTIC HOT WATER SYSTEMS

A. All domestic hot water systems and associated building loop pumps shall be enabled through the DDC system. All domestic hot water systems and pumps shall run continuously. A temperature sensor shall be connected to each hot water system for remote monitoring capability of the domestic hot water temperature. Status of the domestic water pumps shall be monitored by the control system and an alarm shall be generated if a pump fails to operate.

B. The domestic hot water systems shall operate 24 hours a day to prevent bacteria build-up. Once enabled by the DDC system, the domestic hot water heaters shall operate under their factory supplied controls.

C. Tie-in water heaters Lontalk communication.

4.15 CABINET UNIT HEATER CONTROL

A. A room temperature sensor, shall cycle the unit heater fan and valve to maintain desired room space temperature. The unit heater fan shall not be controlled by an aqua-stat.

4.16 EXHAUST FANS

A. Independent exhaust fans in copy rooms shall be enabled by the control system. Status of fan operation shall be monitored via a current monitoring switch. If the exhaust fan fails to start an alarm shall be generated.

B. Exhaust fans will be enabled to operate during building occupied or building purge (cool-down) periods.

4.17 EXHAUST AIR/MAU SYSTEM IN KITCHEN (RTU-4) & EF-3

A. The kitchen MAU and Exhaust fan come as a packaged system on a single curb.

B. The ATC contractor shall interlock the kitchen grease hood exhaust fan with Make-up Air Unit RTU-4. If the kitchen grease hood is in operation, the unit shall be enabled. The ATC contractor shall furnish and install any necessary interlocking relays and switches.

C. The Make-up Air Unit evaporative cooler sump drain and fill valves shall be provided and controlled by the ATC contractor. The sump shall be drained each night at the end of the occupied period. The sump shall be filled each day on a call for cooling as required. If the outside temperature drops below 40 deg. F, the sump shall be drained for freeze protection.
D. The ATC contractor shall interlock the kitchen dishwasher exhaust hood fan EF-3 with the make-up air handler RTU-4 serving the area. If the kitchen dishwasher exhaust hood is in operation, the unit shall be enabled. Conversely, if the make-up air unit (RTU-4) is running, the dishwasher exhaust EF-3 shall be enabled (in order to maintain pressurization.) It is anticipated that the kitchen hood will only be used during RTU-4 occupied hours in which case more than enough make-up air is available. The ATC contractor shall furnish and install any necessary interlocking relays and switches.

E. The ATC contractor shall install and wire the temperature sensors and manual override switches which shall enable the kitchen hoods when the temperature is too great.

F. Daily total runtime of the kitchen exhaust hood and makeup air unit shall be displayed on the graphic page. The daily runtime value shall be recorded for reporting purposes then reset at the end of each day. If the runtime exceeds 12 hours in any one day, an email shall be sent to district personnel.

4.18 FREEZER AND REFRIGERATOR TEMPERATURE ALARMS

A. The ATC contractor shall provide a temperature sensor in each refrigerator and freezer that are tied to the DDC system. The DDC system shall alarm the district Host Computer if the temperatures are out of range.

4.19 FIRE RISER TEMPERATURE MONITORING

A. A temperature sensor shall be provided and connected to the control system to monitor the temperature near the fire risers. If the temperature falls below 45° an alarm shall be generated and an email shall be sent to district personnel.

B. When the temperature falls below 45°, the control system shall enable the hvac equipment serving the area to warm-up the space.

4.20 OUTSIDE AIR TEMPERATURE MONITORING

A. The outside air temperature sensor shall be contained within a wooden instrument enclosure. The location and design of such shall provide a signal to the DDC system that is accurate to within +/- 2 degrees F, regardless of building mass, sun location or other environmental conditions.

B. An additional outside air temperature sensor reading shall be obtained via internet connection to a local weather station. The most accurate and most reliable temperature reading shall be used to control the building.

C. If the internet connection is used, the local sensor shall serve as a backup when the internet reading becomes unreliable.

4.21 GLYCOL FEED SYSTEMS

A. The ATC contractor shall wire all misc. power and pressure sensors provided with the equipment to make the systems completely operational.

4.22 BUILDING ELECTRICAL POWER METERS
A. All building electrical meters shall be monitored by the control system via Lontalk interface.

B. The control system shall log and trend electrical KW demand and daily KWH totals for each meter. Current electrical demand KW, daily peak KW and monthly peak KW shall be monitored and displayed on a graphics page for each meter.

C. Reports shall be created which show the monthly electrical usage in the building.

4.23 HOST COMPUTER & BUILDING GRAPHIC DISPLAY

A. Graphics pages shall be made to match the existing graphics on the districts host computer. Floor plans, air handler summaries, and alarm pages shall all be included.

B. Runtimes of all air handlers, relief fans, exhaust fans, boilers, chillers, and equipment pumps shall be logged at the host computer. The ATC contractor shall provide runtime reports to enable monitoring of the building performance.

4.24 CO2 CONCENTRATION SET POINTS

<table>
<thead>
<tr>
<th>SPACE</th>
<th>CO2 CONCENTRATION SETPOINT (PPM)</th>
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</thead>
<tbody>
<tr>
<td>RECEPTION</td>
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<tr>
<td>CLASSROOM (K-3)</td>
<td>850</td>
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<tr>
<td>CLASSROOM (4+)</td>
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<tr>
<td>CONFERENCE</td>
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END OF SECTION
SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Service meters
7. Mechanical sleeve seals.
8. Grout.
9. Concrete bases.
10. This division is to pay all costs associated with the gas meter that are required by the local gas company/authority.

1.3 DEFINITIONS

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

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig but not more than 5 psig, and is reduced to secondary pressure of more than 0.5 psig but not more than 2 psig.

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

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   3. Pressure regulators. Indicate pressure ratings and capacities.
   4. Dielectric fittings.
   5. Dielectric fittings.
   6. Mechanical sleeve seals.
   7. Escutcheons.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
   1. Shop Drawing Scale: 1/4 inch per foot.

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

D. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

E. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

F. Qualification Data: For qualified professional engineer.

G. Welding certificates.

H. Field quality-control reports.

I. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

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

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

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

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

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

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

1.8 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.

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

C. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: [40] [60]-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.

2.3 JOINING MATERIALS

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


2.4 MANUAL GAS SHUTOFF VALVES

A. 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.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.

4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. BrassCraft Manufacturing Company; a Masco company.
   c. Lyall, R. W. & Company, Inc.
   e. Perfection Corporation; a subsidiary of American Meter Company.

3. Ball: Chrome-plated brass.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Separate packnut with adjustable-stem packing threaded ends.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. BrassCraft Manufacturing Company; a Masco company.
   c. Lyall, R. W. & Company, Inc.
   e. Perfection Corporation; a subsidiary of American Meter Company.

3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
Logan City School District - Ellis Elementary School

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

5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flowserve.
   b. Homestead Valve; a division of Olson Technologies, Inc.
   d. Milliken Valve Company.
   e. Mueller Co.; Gas Products Div.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25.

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

2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 5 psig.
5. Nitrile-rubber valve washer.
7. Threaded end connections complying with ASME B1.20.1.
8. Wall mounting bracket with bubble level indicator.

B. Earthquake Valves: Comply with ASCE 25.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Pacific Seismic Products, Inc.

2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: [0.5 psig] [7 psig] [60 psig].
4. Cast-aluminum body with stainless-steel internal parts.
6. Valve position, open or closed, indicator.
7. Composition valve seat with clapper held by spring or magnet locking mechanism.
8. Level indicator.
2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.


1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Eclipse Combustion, Inc.
   d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   e. Invensys.
   f. Maxitrol Company.
   g. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

2.7 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
2.8 SLEEVES

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

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

2.9 MECHANICAL SLEEVE SEALS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.

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

3. Pressure Plates: Stainless steel.

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

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

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

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

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

E. One-Piece, Stamped-Steel Escutcheons: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Escutcheons: With concealed hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.11 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

2.12 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 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. Install escutcheons at penetrations of interior walls, ceilings, and floors.

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
   f. Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw or spring clips.
h. Piping in Equipment Rooms: One-piece, cast-brass type.
i. Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
j. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. 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.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. 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.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:
a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.4 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.5 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. 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.

D. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
3.6 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 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.
   4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
   5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.7 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.

3.8 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.9 PAINTING

A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
c. Topcoat: Exterior alkyd enamel (semigloss).
d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   c. Topcoat: Interior latex (flat).
   d. Color: Gray.

2. Alkyd System: MPI INT 5.1E.
   c. Topcoat: Interior alkyd (flat).
   d. Color: Gray.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000-psig 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

3.12 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 INDOOR PIPING SCHEDULE
A. Aboveground, piping NPS 2 and smaller shall be the following:
   1. Steel pipe with wrought-steel fittings and welded or threaded joints.
B. Aboveground, piping NPS 2-1/2” and larger shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints.
C. Underground, below building, piping shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints in a vented conduit.
D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.14 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. One-piece, bronze ball valve with bronze trim.
   2. Bronze plug valve.
B. Valves for pipe sizes NPS 2-1/2” and larger at service meter shall be one of the following:
   1. Bronze plug valve.
   2. Cast-iron, nonlubricated plug valve.

END OF SECTION 231123
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Canal-water piping.
   4. Makeup-water piping.
   5. Condensate-drain piping.
   6. Air-vent piping.
   7. Dielectric fittings.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of the following:
   1. Steel pipe and fittings.
   2. Copper pipe, tubing and fittings.
   3. Dielectric fittings.
B. Delegated-Design Submittal:
   1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
   2. Locations of pipe anchors and alignment guides and expansion joints and loops.
   3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.
B. Qualification Data: For Installer.
C. Welding certificates.

D. Field quality-control reports: Written reports as specified in Part 3 of this section including:
   1. Test procedures used.
   2. Test results showing compliance with specified requirements.
   3. Failed test results with corrective action taken to achieve compliance with specified requirements.

1.5 QUALITY ASSURANCE

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

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

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section “Through-Penetration Firestop Systems” for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.


D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.


I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 PLASTIC PIPE AND FITTINGS

A. PP (Polypropylene) Pipe: ASTM F 2389, SDR 7.4 and fiberglass composite reinforced SDR 11.
   1. PP Fusion-weld Socket Fittings: ASTM F 2389.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

G. PP Pipe and Fittings: Manufacturer’s recommended fusion-weld system.

2.5 TRANSITION FITTINGS

A. PP-to-Metal Transition Fittings:

1. Description:
   a. PP one-piece fitting with manufacturer’s Schedule 80 equivalent dimensions.
   b. One end with threaded brass insert and one fusion-socket end.

2.6 DIELECTRIC FITTINGS

A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.

1. Manufacturers:
   a. Advance Products & Systems, Inc.
   c. Capitol Manufacturing Company.
   d. Central Plastics Company.
   e. Elster Perfection.
   f. Grinnell Mechanical Products.
   g. Matco-Norca.
   h. Pipeline Seal and Insulator, Inc.
   i. Precision Plumbing Products, Inc.
   j. Victaulic Company.
   k. Watts Regulator Co.
   l. Zurn Industries, LLC.

B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.

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

D. End Connections: Threaded, or flanged.

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

2.7 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.8 EXTRA MATERIALS

A. Chemicals: Furnish sufficient water treatment chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller shall be [any of] the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be [any of] the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be [any of] the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be [any of] the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Canal-water piping installed belowground and within slabs shall be any of the following:

1. PP, SDR 7.4 pipe; fusion socket fittings; and fusion joints or butt-fusion joints.
2. PP, SDR 11 fiberglass composite reinforced pipe; fusion socket fittings; and fusion joints or butt-fusion joints.
F. Canal-water piping, aboveground, NPS 2 and smaller, shall be [any of] the following:
   1. **Type L**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.
   2. **Schedule 40**, Grade B, Type 96 steel pipe; **Class 125, cast-iron** fittings; cast-iron flanges and flange fittings; and threaded joints.
   3. PP, SDR 7.4 pipe; fusion socket fittings; and fusion joints.
   4. PP, SDR 11 fiberglass composite reinforced pipe; fusion socket fittings; and fusion joints.

G. Makeup-water piping installed aboveground shall be [any of] the following:
   1. **Type L**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.

H. Condensate-drain piping shall be [any of] the following:
   1. **Type M**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

I. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

J. Air-Vent Piping:
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
   2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

K. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

### 3.2 EARTHWORK

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

### 3.3 PIPING INSTALLATIONS

A. **PRE-WORK / PRE-REQUISITES**

   1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
   2. The Contractor shall study the architectural, structural, mechanical, electrical and other drawings to eliminate conflict of piping with other structure lighting or other services.

B. **CONDITION**

   1. All installed pipe lines shall be free from dents, scars, and burrs, with ends reamed smooth.
2. All piping shall be clean and free from acids and loose dirt when installed and shall be kept clean during the completion of the installation.

3. Install piping free of sags and bends.

4. All installed pipe lines shall remain straight against strains tending to cause distortion during system operation. The contractor shall make proper allowance for pipe line expansion and contraction so that no unsightly distortion, noise, damage or improper operation results therefrom.

C. SELECTION

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

2. No street type fittings shall be used.

3. No short nipples shall be used except at drain valves.

4. Plugs of rags, wools, cottons, waste, or similar materials may not be used for plugging.

D. ROUTING/ARRANGEMENT

1. Piping installations shall be neatly organized.

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

3. Install groups of pipes parallel to each other.

4. Install piping spaced to permit application of insulation.

5. Install piping parallel and spaced to permit the servicing of valves.

6. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls or axis of the building.

7. Diagonal runs are prohibited unless specifically indicated otherwise.

8. Install fittings for all changes in direction.

9. No piping shall be run above any electrical panels, electrical equipment or access clearances for electrical for electrical panels or equipment. No piping shall be allowed to run through any electrical rooms.

10. Piping shall be arranged, placed and installed to facilitate equipment maintenance and shall be so arranged to not interfere with the installation of the air-conditioning equipment, ducts, or the removal of other equipment or devices. All specialties shall be so placed to permit easy operation and access.

11. All piping shall be so installed to insure noiseless circulation.

12. Install fittings for all branch connections.
13. Unless otherwise indicated, install branch connections to mains using tee fittings or forged steel branch fittings in main pipe, with the branch connected to the bottom of the main pipe.

14. For up-feed risers, connect the branch to the top of the main pipe.

15. Forged branch fittings shall be installed per the manufacturer’s recommendations.

E. ACCESS / ARRANGEMENT

1. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal. All piping shall be so arranged to not block access to manholes, access openings, etc.

2. Install piping at indicated slopes. If not indicated, install piping at a uniform grade of 0.2 percent where possible, upward in direction of flow. Traps are to be avoided where-ever possible.

3. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

4. When insulated pipes are supported by a roller hanger they shall be protected from damage by suitable pipe covering protection saddles. Saddles shall support pipe on roller and shall be packed with insulation.

5. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

6. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, at each coil on all sides of automatic valves where valves do not have union connections, elsewhere as indicated, and wherever necessary to prevent undue difficulty in making repairs or replacement. Unions are not required at flanged connections.

7. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated. Install flanges on valves, apparatus, and equipment having 2 ½ inch NPS and larger connections. Flanges or unions as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment.

8. Install shutoff valve immediately upstream of each dielectric fitting. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.


10. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

11. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

12. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
13. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS ¾" nipple and ball valve in blow-down connection of strainers NPS 2) and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2).

14. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration-producing equipment.

15. Polypropylene pipe in or passing through plenums must be fire wrapped or installed in a metal conduit.

F. DRAINAGE

1. Drain valves shall be installed at all low points in all piping systems to allow for complete drainage of piping systems.

2. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

3. All piping systems shall be installed so that they can be easily drained by means of drainage of low points of all piping without disconnecting pipe.

4. If not specifically indicated on the drawings, the frequency of draining shall determine whether drain caps, plugs, cocks, or valves are to be used.

G. IDENTIFICATION

1. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

3.4 DIELECTRIC FITTING INSTALLATION

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

1. Install dielectric nipples or waterways in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

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

3. Install Dielectric Fittings into Hydronic Piping Systems: Install dielectric nipples, waterways or couplings to connect piping materials of dissimilar metals.

4. End Connections: Threaded, or flanged.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Steel roof deck shall not be used to support loads from piping, ductwork or equipment, unless noted otherwise. Hanger loads less than 50 lbs. may be hung from the steel roof deck in cases when hanging from the steel roof deck cannot be avoided; the attachment method must distribute the load across the deck as approved by the Structural Engineer.

D. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

E. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 3/8 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 1/2 inch.
6. NPS 3 and Larger: Maximum span, 12 feet; minimum rod size, 1/2 inch.

F. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

G. PVC and CPVC Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

H. PP Piping Hanger Spacing: Install vinyl-coated hangers with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
4. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
5. NPS 6: 48 inches with 3/4-inch rod.
6. NPS 8: 48 inches with 7/8-inch rod.
7. Space all sizes of fiberglass composite reinforced PP pipe according to the manufacturer's written instructions.

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

J. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

K. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

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

3.6 PIPE JOINT CONSTRUCTION

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

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

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


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

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

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

H. PP Fusion Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM D2657 and the manufacturer's recommendations.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
B. Install control valves in accessible locations close to connected equipment.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113
SECTION 232113.13 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Plastic pipe and fittings.
   2. Cased piping system.
   3. Loose-fill insulation.

1.3 PERFORMANCE REQUIREMENTS
A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
   1. Canal-Water Piping: 150 psig (1035 kPa) at 140 deg F (60 deg C).

1.4 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Cased piping.
   2. Loose-fill insulation.
B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.
   1. Calculate requirements for expansion compensation for underground piping.
   2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
   3. Show pipe sizes, locations, and elevations. Show piping in trench, conduit, and cased pipe with details showing clearances between piping, and show insulation thickness.

1.5 INFORMATIONAL SUBMITTALS
A. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and at vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing hydronic piping.
B. Qualification Data: For qualified Installer.
C. Welding certificates.
D. Material Test Reports: For conduit and cased piping.
E. Source quality-control reports.
F. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with provisions in ASME B31.9, "Building Services Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.


PART 2 - PRODUCTS

2.1 STEEL PIPES AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black with plain ends; type, grade, and wall thickness as indicated in "Piping Application" Article.

B. Cast-Iron, Threaded Fittings: ASME B16.4; Class 125.


D. Malleable-Iron Unions: ASME B16.39; Class 150.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Class 125; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Welding Fittings: ASME B16.9 and ASTM A 234/A 234M, seamless or welded.


J. Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and -bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

L. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.2 PLASTIC PIPE AND FITTINGS

A. PP (Polypropylene) Pipe: ASTM F 2389, SDR 7.4 and fiberglass composite reinforced SDR 11.

1. PP Fusion-weld Socket Fittings: ASTM F 2389.

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

2.3 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings One-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cemented- or fusion-joint end.

2.4 CASED PIPING SYSTEM

A. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Insul-Tek Piping Systems, Inc.
   b. Perma-Pipe, Inc.
   c. Rovanco Piping Systems, Inc.
   d. Thermacor Process, L.P.
   e. Thermal Pipe Systems.
   f. Urecon Ltd.

B. Carrier Pipe: Schedule 40, steel pipe and fittings.

C. Carrier Pipe Insulation:

1. Polyurethane Foam Pipe Insulation: Rigid, cellular, high-pressure injected between carrier pipe and jacket.
a. Comply with ASTM C 591; thermal conductivity (k-value) shall not exceed 0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.

D. Casing: HDPE.

E. Casing accessories include the following:
   1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
   2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
   3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

F. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

2.5 LOOSE-FILL INSULATION

A. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   2. Thermal Conductivity (k-Value): 0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).
   3. Application Temperature Range: 35 to 800 deg F (2 to 426 deg C).
   4. Dry Density: 40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).
   5. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

PART 3 - EXECUTION

3.1 EARTHWORK

A. See Section 312000 “Earth Moving” for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

A. Canal-Water Piping:
   1. NPS 2 and smaller shall be any of the following:
      a. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
      b. Schedule 4 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
      c. SD 7.4 PP pipe with PP fusion socket fittings and fusion joints or butt-fusion joints.
      d. SD 11 fiberglass composite reinforced PP pipe with PP fusion socket fittings and fusion joints or butt-fusion joints.
2. NPS 2-1/2 and larger shall be any of the following:
   a. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
   b. Schedule 40 steel pipe, wrought-steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
   c. SD 7.4 PP pipe with PP fusion socket fittings and fusion joints or butt-fusion joints.
   d. SD 11 fiberglass composite reinforced PP pipe with PP fusion socket fittings and fusion joints or butt-fusion joints.

3. Cased piping with polyurethane carrier-pipe insulation.
   a. Piping Insulation Thickness: 2 inches (50 mm).

3.3 PIPING INSTALLATION

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

B. Remove standing water in the bottom of trench.

C. Do not backfill piping trench until field quality-control testing has been completed and results approved.

D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.

E. Install components with pressure rating equal to or greater than system operating pressure.

F. Install piping free of sags and bends.

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

H. See Section 230517 "Sleeves and Sleeve Seals for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

I. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

3.4 LOOSE-FILL INSULATION INSTALLATION

A. Do not disturb the bottom of trench; otherwise, compact and stabilize it to ensure proper support.

B. Remove standing water in the bottom of trench.

C. Bed the pipe on a minimum 6-inch (150-mm) layer of granular fill material with a minimum 6-inch (150-mm) clearance between the pipes.

D. Form insulation trench by excavation or by installing drywall side forms to establish required height and width of the insulation.
E. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.

F. Place insulation and backfill after field quality-control testing has been completed and results approved.

G. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. See Section 033000 "Cast-in-Place Concrete" for concrete and reinforcement.

H. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.

I. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.

J. Remove temporary hangers and supports.

K. Cover loose-fill insulation with polyethylene sheet a minimum of 4 mils (0.10 mm) thick, and empty loose-fill insulation bags on top.

L. Manually backfill 6 inches (150 mm) of clean backfill. If mechanical compaction is required, manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.

### 3.5 JOINT CONSTRUCTION

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

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

C. PP Fusion Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

   1. Comply with ASTM D2657 and the manufacturer’s recommendations.

D. Cased Piping Joints: Assemble sections according to the manufacturer’s instructions. Finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

### 3.6 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

### 3.7 FIELD QUALITY CONTROL

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

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
   c. Use vents installed at high points to release trapped air while filling system.

2. Test hydronic piping as follows:
   a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
   b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

E. Prepare test and inspection reports.

END OF SECTION 232113.13
SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes special-duty valves and specialties for the following:
   1. Hot-water heating piping.
   2. Makeup-water piping.
   3. Condensate-drain piping.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of the following:
   1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   2. Air-control devices.
   3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 VALVES
A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping. Gate valves are not allowed on this project.
B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC.

C. Refer to Part 3 “Valve Applications” Article for applications of each valve.

D. Bronze, Calibrated-Orifice or Venturi, Balancing Valves, NPS 2 and smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Taco.
   g. Tour & Andersson; available through Victaulic Company.
   h. Nexus Valve, Inc.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
8. Handle Style: Lever, with memory stop to retain set position.
10. Maximum Operating Temperature: 250 deg F.

E. Cast-Iron or Steel, Calibrated-Orifice or Venturi, Balancing Valves, NPS 2 ½ and larger:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Flow Design Inc.
   e. Gerand Engineering Co.
   f. Grinnell.
   g. Griswold Controls.
   h. Taco.
   i. Tour & Andersson; available through Victaulic Company.
   j. Spence Engineering Company Inc.
   k. Watts Regulator Co.
   l. Nexus Valve, Inc.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
9. Handle Style: Lever, with memory stop to retain set position.
11. Maximum Operating Temperature: 250 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Brass, removable without system shutdown.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Conbraco Industries, Inc.
   e. Kunkle.
   f. Spence Engineering Company, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
8. Inlet Strainer: Brass, removable without system shutdown.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

H. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump.
c. Flow Design Inc.
d. Griswold Controls.
e. Taco
f. Nexus Valve, Inc.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Tamper proof, self-cleaning, and removable, for inspections and replacement.
   a. Corrosion resistant.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Attached by chain and marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations:
8. Maximum Operating Temperature: 200 deg F.
9. Fitted with pressure and temperature test valves.
10. Equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amtrol, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett Domestic Pump.
      d. Taco, Inc.
   2. Body: Bronze.
   3. Internal Parts: Nonferrous.
   4. Operator: Screwdriver or thumbscrew.
   5. Manually operated with ball valve in the down position.
   8. CWP Rating: 150 psig.
   9. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amtrol, Inc.
      b. Bell & Gossett Domestic Pump.
      c. Hoffman Specialty ITT; Fluid Handling Div.
      d. Spirax-Sarco.
e. Spirovent.
f. Taco, Inc.
g. Honeywell-Baukman.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
5. Inlet Connection: NPS 1/2.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. **Bladder** - Type Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

3. **Bladder**: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.

5. Access: Drain fitting and taps for pressure gage.
6. Support:
   a. Vertical tanks with steel legs or base.
   b. Horizontal tanks with steel saddles.

D. **Tangential-Type Air Separators**:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.

2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 240 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
2.3 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Hoffman Specialty ITT; Fluid Handling Div.
   c. Metraflex Co.
   d. Mueller
   e. Spirax Sarco.
   f. Trane Co.
   g. Tour & Andersson; available through Victaulic Company.
   h. Watts Regulator Co.
   i. Nexus Valve

2. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless-steel, or perforated stainless-steel basket:
   a. 20-mesh strainer.
5. CWP Rating: 125 psig.

B. Basket Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.
   b. Metraflex Co.
   c. Mueller
   d. Spirax Sarco.
   e. Tour & Andersson; available through Victaulic Company.

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

C. Spherical, Rubber, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amber-Booth.
   b. Mason Industries.
   c. Metraflex Co.
   d. Flex-Weld.
   e. Fugate.
f. Twin City Hose.
g. Nexus Valve, Inc.

3. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

D. Diverting Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amtrol, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett Domestic Pump.
      d. Taco, Inc.
   2. Body: Cast Iron or Wrought Copper
   3. Ends: Threaded or Soldered
   5. CWP Rating: 125 psig.
   6. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Automatic air vents may cause damage to ceilings and other finished surfaces. Air vents aid in system filling. Air removal after initial startup is accomplished by air separator or boiler diptube. Manual air vents may be a better solution.
C. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

E. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

F. Install tangential air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.

G. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

H. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116
PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   2. Close-coupled, end-suction centrifugal pumps.
   3. Domestic water recirculation pumps

1.3 DEFINITIONS
A. Buna-N: Nitrile rubber.
B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of pump. Include certified performance curves and rated capacities, shipping weights, installed weights, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.
      a. Detail all wiring systems and differentiate clearly between manufacturer-installed and field-installed wiring.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.
1.6 QUALITY ASSURANCE

A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.

B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

C. Regulatory Requirements: Fabricate and test steam condensate pumps to comply with HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and HI 1.6, "Centrifugal Pump Tests."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.8 COORDINATION

A. Coordinate size and location of concrete bases.

PART 2 - PRODUCTS

2.1 FACTORY STOCK CIRCULATORS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Crane Pumps & Systems.
4. Flofab
5. Flowserve Corporation.
7. ITT Corporation; Bell & Gossett.
8. Mepco, LLC.
11. TACO Incorporated.
12. Thrush Company Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, in-line or motor mounted pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rated for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded or threaded companion-flange or union-end connections or unions at connections for casings that are not available with threaded companion flanges.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw.
3. Pump Shaft: Steel, with oil lubricated copper-alloy shaft sleeve.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings:
   a. Oil lubricated, bronze-journal.

D. Motor: Single speed and rigidly or resiliently mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   a. Enclosure: Open, dripproof.
   b. Enclosure Materials: Cast iron.
   c. Motor Bearings: Permanently lubricated ball bearings.
   d. Efficiency: Premium efficient.
   e. Service Factor: 1.15

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Flofab
5. ITT Corporation; Bell & Gossett.
6. Mepco, LLC.
7. PACO Pumps; Grundfos CBG.
9. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, inline pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rated for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded or threaded companion-flange or union-end connections or unions at connections for casings that are not available with threaded companion flanges.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
   3. Pump Shaft: Steel, with oil lubricated copper-alloy shaft sleeve.
   4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
   5. Pump Bearings:
      1. Oil lubricated, bronze-journal.

D. Motor: Single speed and rigidly or resiliently mounted to pump casing.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Enclosure: Open, dripproof.
      b. Enclosure Materials:
         1) Cast iron.
      c. Motor Bearings:
         1) Grease-lubricated ball bearings.
      d. Efficiency:
         1) Premium efficient.
      e. Service Factor: 1.15

2.3 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Pumps Inc.
   2. Aurora Pump; Division of Pentair Pump Group.
   3. Flofab
   4. ITT Corporation; Bell & Gossett.
   5. ITT Corporation; Goulds Pumps.
   6. PACO Pumps; Grundfos CBG.
   7. Patterson Pump Co.; a subsidiary of the Gorman-Rupp Co.
9. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rated for $175$-psig minimum working pressure and a continuous water temperature of $225$ deg F.

C. Pump Construction:

1. Casing: Radially split, cast iron, bronze fitted, with drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and threaded flanged or companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft:
   a. Steel, with oil lubricated copper-alloy shaft sleeve.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings:
   a. Oil lubricated, bronze-journal.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   a. Enclosure: Open, dripproof.
   b. Enclosure Materials: Cast iron.
   d. Efficiency:
      1) Premium efficient.
   e. NEMA Design:
   f. Service Factor: 1.15

2.4 DOMESTIC WATER PUMPS

A. Casings and all wetted parts in pumps used in domestic water systems shall be stainless steel.

B. See Division 22 Section “Domestic Water Pumps”.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
Logan City School District - Ellis Elementary School

1. Angle pattern.
2. **175-psig** pressure rating, **cast-iron** body and end cap, pump-inlet fitting.
3. Bronze startup and **bronze** or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. **Factory-fabricated** support.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

**3.2 PUMP INSTALLATION**

A. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

B. Comply with HI 1.4.

C. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

D. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

E. **Automatic Condensate Pump Units:** Install units for collecting condensate and extend to open drain.

F. **Equipment Mounting:**
   1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03 "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."

G. **Equipment Mounting:** Install in-line pumps with continuous-thread hanger rods and spring hangers **elastomeric hangers** of size required to support weight of in-line pumps.
   1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. **Engage a factory-authorized service representative to perform** alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Section "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. **Install check, shutoff, and throttling** on discharge side of pumps.

E. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

F. Install **suction diffuser** and shutoff valve on suction side of vertical-inline and base-mounted pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. Install thermometers at pump suction and discharge.

J. Install check valve and gate or ball valve on each condensate pump unit discharge.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   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 and UL 486B.

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
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 and UL 486B.

3.5 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. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
   a. Verify that electrical wiring installation complies with manufacturer's written instructions and the Contract Documents.
   b. Verify bearing lubrication.
   c. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   d. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Open cooling water-supply valves in cooling water supply to bearings, where applicable.
7. Open cooling water-supply valves if stuffing boxes are water cooled.
8. Open sealing liquid-supply valves if pumps are so fitted.
9. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
10. Open circulating line valves if pumps should not be operated against dead shutoff.
12. Open discharge valve slowly.
13. Observe leakage from stuffing boxes and adjust sealing liquid valve for proper flow to ensure lubrication of packing. Let packing "run in" before reducing leakage through stuffing boxes; then tighten glands.
14. Check general mechanical operation of pumps and motors.
15. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

B. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except open discharge valves before starting motors.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section Contract Closeout.
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.
END OF SECTION 232123
SECTION 232500 – HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:
   2. HVAC System cleaning and treatment Chemicals.
   3. Chemical treatment test equipment.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Bypass feeders.
   2. Chemical test equipment.
   3. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certificates: For components, from manufacturer.
   1. Submit certification that the manufactured equipment and components will withstand seismic forces defined in Section 239548 “Vibration and Seismic Controls for HVAC”.
   2. Basis for Certification: Indicate whether Withstand Certification is based on actual test of assembled components or on calculation.
      a. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to seismic forces specified
   3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.
C. Other Informational Submittals:
   1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities and applying water treatment as specified in this Section.

B. Mechanical Equipment Contractor: Responsibilities to include installation of water-treatment equipment under the direction of the HVAC Water-Treatment Service Provider (above).

C. 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.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
   1. Initial and periodic water analysis and HVAC water-treatment recommendations.
   2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
   3. At quarterly intervals following Substantial Completion provide field service and consultation.
   5. Laboratory technical analysis.
   6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Power Engineering Co. (PECO)
   2. Other than Power Engineering shall obtain written prior approval.
2.2 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. HVAC water treatment and cleaning formulated based on the water quality at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, shall have the following water qualities:

1. Closed hydronic systems, including:
   a. Heating - hot-water system;
   b. Heating - glycol/water system;
   c. Cooling - chilled water system;
   d. Cooling - chilled glycol/water system;
   e. Dual-temperature water system;
   f. Snowmelt with glycol/water.

2. pH: Maintain a value within 8.8 to 9.5
3. Nitrite: Maintain a value within 800 to 1000 ppm.
4. Soluble Copper: Maintain copper coupon corrosion rates less than 0.20 mpy.
5. TDS: Maintain a maximum value of 3000 ppm
7. Microbiological Limits:
   a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
   b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
   c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
   d. Sulfate Reducers: Maintain a maximum value of zero (0) organisms/mL.
   e. Iron Bacteria: Maintain a maximum value of zero (0) organisms/mL.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.


2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing: total hardness drop, phosphate, sodium nitrate, for closed hydronic systems.

2.5 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Glycol Feed System:
1. One (1) 50-gallon polyethylene feed tank. Wall thickness shall be a minimum of ¼”. Tank shall be mounted on a steel frame with accommodations for mounting a pump underneath. Tank shall be supplied with a removable lid and all interconnecting piping to pump including strainer and isolation valve. Tank height including stand shall not exceed 48”. Tank stand shall be finished with an epoxy powder coating to protect against corrosion.

2. One (1) Level switch to deactivate pump and activate alarm on low glycol level in the feed tank.

3. One (1) Control panel shall house switching device for pump, audible alarm, HOA switch for pump, lights to indicate power and low level, pushbutton for alarm silence. Enclosure shall be NEMA 12. Control panel shall be mounted on the tank stand.

4. One (1) 1/3 HP centrifugal pump mounted under the feed tank. Materials of construction shall be bronze. Pump shall provide 2.5 GPM at 60 PSIG. Rotary gear pump is not acceptable.

5. One (1) Pressure switch shall be Honeywell L404F1078 or Square D 9012 GNG-4. Switch pressure at: [Field determine pressure to activate the glycol feed pump] [Field determine differential setting for the pressure switch.]

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in “Performance Requirements” Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Contractor Responsibilities:

1. Water Treatment Contractor:
   a. Provide water treatment equipment.
   b. Provide fluids,
   c. Chemicals.
   d. Make adjustments.

2. Mechanical Contractor:
   a. Install equipment per Water Treatment Contractors instructions.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install glycol feed system per manufacturers recommendations.
E. Bypass Feeders: Install in closed hydronic systems, and equipped with the following:
   1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
   2. Install full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
   3. Install a swing check on the inlet after the isolation valve.

F. Cleaning:
   1. After completing system installation, inspect exposed finish. Remove burrs, dirt. And construction debris; repair damaged finishes, including chips scratches and abrasions.
   2. Ensure system is operational, filled, started and vented prior to cleaning. Place terminal control valves in OPEN position during cleaning. Use water meter to record capacity of each system.
   3. Add cleaning chemicals as recommended by manufacturer. Circulate for 48-hours, then drain. Refill with clean water and circulate for 24-hours, then drain. Refill with clean water and repeat until system cleaning chemicals are removed.

3.3 CONNECTIONS
A. Where installing piping adjacent to equipment, allow space for service and maintenance.
B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."
C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."
D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

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

D. Prepare written test and inspection reports. Include written reports with Close Out Submittals

E. At quarterly intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that manual chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Meet and consult with Owner's maintenance personnel. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

5. Copper: ASTM D 1688
6. pH: ASTM D 5464

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to adjusting, operating, startup and shutdown; troubleshooting; servicing and preventative maintenance of the HVAC Water Treatment Systems.

1. Review data in the Operation and Maintenance Manual. Refer to Division 1 Section "Contact Closeout".
2. Schedule training with Owner through the Architect with at least 14 days advance notice.

END OF SECTION 23 2500
SECTION 233001 - COMMON DUCT REQUIREMENTS

PART 1 - PRODUCTS

1.1 SUMMARY
   A. Includes But Not Limited To:
      1. General procedures and requirements for ductwork.
      2. Repair leaks in ductwork, as identified by smoke test, at no additional cost to Owner.
      3. Soundproofing procedures for duct penetrations of walls, ceilings, and floors in mechanical equipment rooms.
   B. Related Sections:
      1. Division 07: Quality of Acoustic Sealant.
      2. Section 23 0500: Common Work Results for HVAC
      3. Section 23 0593: Testing Adjusting and Balancing for HVAC.

1.2 SUBMITTALS
   A. Samples: Sealer and gauze proposed for sealing ductwork.
   B. Quality Assurance / Control:
      1. Manufacturer’s installation manuals providing detailed instructions on assembly, joint sealing, and system pressure testing for leaks.
      2. Specification data on sealer and gauze proposed for sealing ductwork.

1.3 QUALITY ASSURANCE
   A. Requirements: Construction details not specifically called out in Contract Documents shall conform to applicable requirements of SMACNA HVAC Duct Construction Standards.
   B. Pre-Installation Conference: Schedule conference immediately before installation of ductwork.

PART 2 - PRODUCTS

2.1 Finishes, Where Applicable: Colors as selected by Architect.

2.2 Duct Hangers:
   A. One inch by 18 ga galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches apart. Do not use wire hangers.
1. Attaching screws at trusses shall be 2 inch No. 10 round head wood screws. Nails not allowed.
2. Attach threaded rod to steel joist with Grinnell Steel washer plate Fig. 60 - ph-1. Double nut connection.

2.3 Penetration Soundproofing Materials:
   A. Insulation for Packing: Fiberglass.
   B. Calking: Polysulphide.
   C. Escutcheon Frame: 22 ga galvanized iron 2 inches wide.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
   B. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
   C. Hangers And Supports:
      1. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.
      2. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
      3. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
      4. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
      5. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing, and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.
   D. Penetration Soundproofing
      1. Pack space between ducts and structure full of fiberglass insulation of sufficient thickness to be wedged tight, allowing space for application of calking.
      2. Provide calking at least 2 inches thick between duct and structure on both ends of opening through structure.
      3. Provide metal escutcheon on Equipment Room side. Secure escutcheon to wall.

3.2 CLEANING
   A. Clean interior of duct systems before final completion.
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Single-wall rectangular ducts and fittings.
      2. Single-wall **round** ducts and fittings.
      4. Duct liner.
      5. Sealants and gaskets.
      6. Hangers and supports.

   B. Related Sections:
      1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and
         balancing requirements for metal ducts.
      2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-
         mounting access doors and panels, turning vanes, and flexible ducts.
      3. Section 230713 “Duct Insulation” for duct insulation and fire wrap.

1.3 PERFORMANCE REQUIREMENTS
   A. Delegated Duct Design:  Duct construction, including sheet metal thicknesses, seam and joint
      construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC
      Duct Construction Standards - Metal and Flexible" and performance requirements and design
      criteria indicated in "Duct Schedule" Article.

   B. Airstream Surfaces:  Surfaces in contact with the airstream shall comply with requirements in
      ASHRAE 62.1.

1.4 ACTION SUBMITTALS
   A. Product Data:  For each type of the following products:
      1. Liners and adhesives.
      2. Sealants and gaskets.

   B. Shop Drawings:
      1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors
and panels.
12. Hangers and supports, including methods for duct and building attachment and
vibration isolation.
13. Duct fabrication shall not begin until shop drawings have been submitted and reviewed
by the mechanical engineer.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

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

1. Duct installation in congested spaces, indicating coordination with general construction,
building components, and other building services. Indicate proposed changes to duct
layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including, but not limited to the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to [AWS D1.1/D1.1M,
"Structural Welding Code - Steel," for hangers and supports.] [AWS D1.2/D1.2M,
"Sheet Metal Welding Code," for duct joint and seam welding.]
B. Welding Qualifications: Qualify procedures and personnel according to the following:


C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Duct dimensions shown on drawings are inside clear dimensions.

E. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

B. Duct dimensions shown on drawings are inside clear dimensions.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support
interervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 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."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: **0.27 Btu x in./h x sq. ft. x deg F** at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: **0.25 Btu x in./h x sq. ft. x deg F** at 75 deg F mean temperature.

H. **Inner Duct:** Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent. Inner duct shall be solid sheet steel a minimum of 10 feet downstream of humidifiers or air washers.

I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 **SINGLE-WALL ROUND DUCTS AND FITTINGS**

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Duct dimensions shown on drawings are inside clear dimensions.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Not allowed.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DOUBLE-WALL ROUND DUCTS AND FITTINGS

A. Duct dimensions shown on drawings are inside clear dimensions.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "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."

   a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. Longitudinal Seams: Not allowed.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

   1. Inner duct shall be solid sheet steel a minimum of 10 feet downstream of humidifiers and/or air washers.

D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

   1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.
   4. Cover insulation with polyester film complying with UL 181, Class 1.

E. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
2.5 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653.
   1. Galvanized Coating Designation: **G90**.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36, 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.

D. Tie Rods: Galvanized steel, **1/4-inch** minimum diameter for lengths **36 inches** or less; **3/8-inch** minimum diameter for lengths longer than **36 inches**.

2.6 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.
   2. Maximum Thermal Conductivity:
      a. Type I, Flexible: **0.27 Btu x in./h x sq. ft. x deg F** 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.
   3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   4. Water-Based Liner Adhesive:
      a. Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      b. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA Inc.
   b. Armacell LLC.
   c. Rubatex International, LLC

2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. 0.135-inch-diameter shank.

2. Insulation-Retaining Washers: With beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Self-locking washers formed from 0.016-inch-thick aluminum.

D. 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. 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.

7. 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.

8. 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.

9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.7 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor or outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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.

D. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   7. Mold and mildew resistant.
   8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: **10-inch wg**, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

2. Type: S.
3. Grade: NS.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. 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.

**2.8 HANGERS AND SUPPORTS**

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 5-1**, "Rectangular Duct Hangers Minimum Size," and **Table 5-2**, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.


3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct. [20 feet]

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

D. Perform a light test of grease ductwork per 2012 International Mechanical Code paragraph 506.3.2.5. prior to concealment by insulation or covered by shaft.

   1. Perform light test in the presence of local Inspector/Engineer.
   2. Document whether test passed or failed.
   3. Repair any joints or duct welds that fail light test to the point the ductwork passes the light test.

E. Install grease duct with minimum clearance to combustibles as required by IBC and local codes. Installations that do not meet the minimum required clearances shall be fire wrapped as specified in Section 230713 "Duct Insulation".

F. Provide approved fire-wrap insulation that meets ASTM C 656.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   2. Outdoor, Supply-Air Ducts: Seal Class A.
   3. Outdoor, Exhaust Ducts: Seal Class A.
   4. Outdoor, Return-Air Ducts: Seal Class A.
   5. Outdoor, Return-Air Ducts: Seal Class [C.]
6. **Unconditioned Space, Supply-Air Ducts in Pressure Classes** 2-Inch wg and Lower: Seal Class A.

7. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

8. **Unconditioned Space, Exhaust Ducts:** Seal Class A.

9. **Unconditioned Space, Return-Air Ducts:** Seal Class A.

10. **Conditioned Space, Supply-Air Ducts in Pressure Classes** 2-Inch wg and Lower: Seal Class A.

11. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

12. **Conditioned Space, Exhaust Ducts:** Seal Class A.

13. **Conditioned Space, Return-Air Ducts:** Seal Class A.

### 3.5 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.

### 3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with the requirements specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.7 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.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   2. Test the following systems:
      a. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      b. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      c. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      d. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.

   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
   6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Any liner showing evidence that is has wet at any time shall be removed and replaced with new liner.
   a. Disinfect affected sheet metal, and pins.
   b. Install new liner per specifications
   c. Seal friable edges and seams of repaired liner.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. Clean new duct system before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
   1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling to gain access during the cleaning process.

C. 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.

D. 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.

E. 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 according to NADCA 1992. 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 according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel.
B. Ductwork running in areas where there are no ceilings or when noted on the drawings shall be doubled wall duct and shall meet the requirements indicated below.
C. Supply Ducts:
   1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. Minimum SMACNA Seal Class: A.
      d. SMACNA Leakage Class for Rectangular: 16.
      e. SMACNA Leakage Class for Round: 8.
   2. Ducts Connected to Constant-Volume Air-Handling Units:
      a. Pressure Class: Positive 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 8.
      d. SMACNA Leakage Class for Round: 4.
   3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
      a. Pressure Class: Positive 6-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 4.
      d. SMACNA Leakage Class for Round: 2.
4. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive 4-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round: 2.

D. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round: 8.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round: 8.

3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round: 4.

E. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round: 4.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round: 4.
3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Pressure Class: Positive **6-inch wg**.
   b. Minimum SMACNA Seal Class: **A**.
   c. SMACNA Leakage Class for Rectangular: **4**.
   d. SMACNA Leakage Class for Round: **2**.

4. Ducts Connected to Type I (Grease) Commercial Kitchen Hoods: Comply with NFPA 96.
   a. Exposed to View: 18 gauge Type 304, stainless-steel sheet, No. 4 finish.
   b. Concealed: 16 gauge black steel.
   c. Pressure Class: Positive or negative **3-inch wg**.
   d. Welded seams and joints.
   e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
   f. SMACNA Leakage Class: **2**.
   g. A light test shall be performed for grease duct prior to concealing the duct.

5. Ducts Connected to Type II (Heat) Commercial Kitchen Hoods:
   a. Type 304, stainless-steel sheet.
   b. **Exposed to View**: No. 4 finish.
   c. Pressure Class: Positive or negative **3-inch wg**.
   d. Concealed: No. 2D finish.
   e. Welded seams and joints.
   f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
   g. SMACNA Leakage Class: **2**.

6. Ducts Connected to Dishwasher and Low Temperature Vapor and Odor Hoods:
   a. Type 304, stainless-steel sheet.
   b. **Exposed to View**: No. 4 finish.
   c. Pressure Class: Positive or negative **3-inch wg**.
   d. Concealed: No. 2D finish.
   e. Welded seams and flanged joints with watertight EPDM gaskets.
   f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations, flanged joints class A.
   g. SMACNA Leakage Class: **2**.

7. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative **4-inch wg**.
   b. Minimum SMACNA Seal Class: **A**.
   c. SMACNA Leakage Class for Rectangular: **4**.
   d. SMACNA Leakage Class for Round: **2**.
F. 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 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round: 4.

3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round: 4.

G. Intermediate Reinforcement:


2. PVC-Coated Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Stainless-Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.


H. Duct Liner Restrictions:

1. Duct Liner exposed to air movement shall not be used on medium pressure ductwork (2000 to 4000 FPM velocity). See section 230713 “Duct Insulation” for insulation requirements.

2. Duct Liner exposed to air movement shall not be used on high pressure ductwork (Greater than 4000 FPM velocity). See section 230713 “Duct Insulation” for insulation requirements.
3. All duct liner shall meet all of the requirements found in 2012 IECC

I. Liner: (Ductwork located in Unconditioned space)

1. Low Pressure Supply Air Ducts (Less than 2000 FPM velocity): *Fibrous glass, Type I*, 1-1/2 inch thick with a minimum R value of 6.0 for ducts in unconditioned spaces.

2. Supply Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick for ducts in conditioned spaces.

3. Return Air Ducts: *Fibrous glass, Type I*, 1-1/2 inch thick with a minimum R value of 6.0 for ducts in unconditioned spaces.

4. Return Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick for ducts in conditioned spaces.

5. Exhaust Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick.


7. Return- and Exhaust-Fan Plenums: *Fibrous glass, Type II*, 1-1/2 inch thick with a minimum R value of 6.0.

8. Transfer Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick. [1-1/2 inches] [2 inches].

J. Liner: (Ductwork located Interior to building Insulated Envelope)

1. Low Pressure Supply Air Ducts (Less than 2000 FPM velocity): *Fibrous glass, Type I*, 1 inch thick with a minimum R value of 4.0 for ducts in unconditioned spaces.

2. Supply Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick for ducts in conditioned spaces.

3. Return Air Ducts: *Fibrous glass, Type I*, 1 inch thick with a minimum R value of 4.0 for ducts in unconditioned spaces.

4. Return Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick for ducts in conditioned spaces.

5. Exhaust Air Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick.

6. Supply Fan Plenums: *Fibrous glass, Type I*, 1 inch thick with a minimum R value of 4.0.

7. Return- and Exhaust-Fan Plenums: *Fibrous glass, Type II*, 1 inch thick with a minimum R value of 4.0.

8. Transfer Ducts: *Fibrous glass, Type I* [or flexible elastomeric] [Natural fiber], 1 inch thick. [1-1/2 inches] [2 inches].

K. Double-Wall Duct Interstitial Insulation:
1. Supply Air Ducts: **1-1/2 inch** thick with a minimum R value of 6.0.
2. Return Air Ducts: **1-1/2 inch** thick with a minimum R value of 6.0.
3. Exhaust Air Ducts: **1-1/2 inch** thick with a minimum R value of 6.0.

L. Exterior Ductwork Liner Insulation:
1. Supply Air Ducts: **2 inch** thick with a minimum R value of 8.0.
2. Return Air Ducts: **2 inch** thick with a minimum R value of 8.0.
3. Exhaust Air Ducts: **2 inch** thick with a minimum R value of 8.0.

M. Elbow Configuration:
1. 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."

2. 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: 1.0 radius-to-diameter ratio and three segments for 90-degree elbow.
   2) Velocity **1000 to 1500 fpm**: 1.5 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: Welded.

N. 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 high efficiency take-off.
   b. Rectangular Main to Round Branch: 45-degree entry high efficiency take-off.
2. **Round:**
   
a. 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.
b. Velocity **1000 to 1500 fpm**: 45-degree entry high efficiency tap.
c. Velocity **1500 fpm** or Higher: 45-degree lateral.

END OF SECTION 233113
SECTION 233119 - HVAC CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Factory-fabricated, field-assembled, single- and double-wall casings for HVAC equipment.

1.3 PERFORMANCE REQUIREMENTS

A. Static-Pressure Classes:
   1. Upstream from Fan(s): 2-inch wg.
   2. Downstream from Fan(s): 4-inch wg.

B. Structural Performance:
   1. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot of width.
      a. Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. and snow load of 30 lbf/sq. ft..

C. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type of the following products:
   1. Factory-fabricated casings.
   2. Liners and adhesives.
   3. Sealants and gaskets.

B. Shop Drawings: For HVAC casings. Include plans, elevations, sections, components, and attachments to other work.
1. Detail HVAC casing assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Sheet metal thickness(es).
3. Reinforcement and spacing.
4. Seam and joint construction.
5. Access doors including frames, hinges, and latches.
6. Filter, coil, humidifier, and other apparatus being installed in and mounted on casing.
7. Locations for access to internal components.
8. Hangers and supports including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
9. Interior lighting, including switches.

C. Welding certificates.

D. Product Certificates: For acoustically critical casings, from manufacturer.

1. Show sound-absorption coefficients in each octave band lower than those scheduled when tested according to ASTM C 423.
2. Show airborne sound transmission losses lower than those scheduled when tested according to ASTM E 90.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE


B. Welding Qualifications: Qualify procedures and personnel according to the following:


1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate sizes and locations of steel supports. Supports are specified in Division 05 Section "Metal Fabrications."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 GENERAL CASING FABRICATION REQUIREMENTS
A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 6, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

1. Fabricate casings with more than 3-inch wg negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
2. Casings with more than 2-inch wg positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Exterior Surface Galvanized Coating Designation: G90.
2. Interior Surface Galvanized Coating Designation:
   a. Sections Not Exposed to Moisture: G90.
   b. Sections Housing and Downstream from Cooling Coil and Humidifiers: G90.

C. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating 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 according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.

F. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.

G. Access Doors: Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-11, "Casing Access Doors - 2-inch wg," and Figure 6.12, "Casing Access Doors - 3-10-inch wg"; and according to pressure class of the plenum or casing section in which access doors are to be installed.

1. Size: 20 by 54 inches.
3. Hinges: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Latches: Minimum of two wedge-lever-type latches, operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Doors shall open against air pressure.
H. Condensate Drain Pans: Formed sections of Type 304, stainless-steel sheet complying with requirements in ASHRAE 62.1. Pans shall extend a minimum of 12 inches past coil.

1. Double-wall construction shall have space between walls filled with foam insulation and sealed moisture tight.
2. Intermediate drain pan or drain trough shall collect condensate from top coil for units with stacked coils or stacked eliminators.
3. Insulation: Polystyrene or polyurethane.
4. Slopes shall be in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
5. Each drain pan connection shall have a trap. Drain traps with depth and height differential between inlet and outlet equal or greater to the design static pressure plus 2-inch wg. Include slab height in trap calculation.

2.2 SHOP-FABRICATED CASINGS

A. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

B. Double-Wall Casing Inner Panel: Solid sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

C. Interstitial Insulation: Polyurethane foam complying with NFPA 90A or NFPA 90B.

D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Coat insulation with antimicrobial coating.
3. Cover insulation with polyester film complying with UL 181, Class 1.

E. Interstitial Insulation: Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

F. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.

G. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90.

H. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.

I. Reinforce casings with galvanized-steel angles.
2.3 MANUFACTURED CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing.

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

1. Acoustical Surfaces, Inc.
2. AeroSonic, Inc.; a division of TUTCO, Inc.
4. CertainTeed Corp.; Insulation Group.
5. CLEANPAK International.
6. D&D Sound Control.
7. IACL.
8. Industrial Noise Control, Inc.
9. McGill AirSilence LLC.
10. Ruskin.
11. SEMCO Incorporated.

C. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid perforated, galvanized sheet steel interior wall; with space between wall filled with insulation.

1. Wall Thickness: 2 inches 4 inches.
2. Fabricate with a minimum number of joints.
3. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
4. Sheet metal thickness shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
5. Sheet Metal Thicknesses:
   a. Exterior Wall Thickness: 0.040 inch minimum.
   b. Interior Wall Thickness: 0.034 inch minimum.

8. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.
9. Fabricate panels with continuous tongue-and-groove or self-locking joints effective inside and outside each panel.

D. Trim Items: Fabricate from a minimum of 0.052-inch galvanized sheet steel, furnished in standard lengths for field cutting.

2.4 CASING LINER

A. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.; Insulation Group.
2. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

B. Natural-Fiber Casing Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor, and complying with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bonded Logic, Inc.
   b. Reflectix Inc.

2. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested according to ASTM C 518.

3. 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.

4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

C. 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- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized steel, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing 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 casings or cut and fit to ensure butted-edge overlapping.
5. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm.
6. 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.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined casing preceding unlined duct.
c. Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm or where indicated.

8. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

2.5 SEALANT MATERIALS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   8. Service: Indoor or outdoor.

C. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   7. Mold and mildew resistant.
   8. VOC: Maximum 395 g/L.
   9. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   10. Service: Indoor or outdoor.
   11. Substrate: Compatible with galvanized sheet steel or stainless steel.

D. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine concrete bases, roof curbs, and steel supports for compliance with requirements for conditions affecting installation and performance of HVAC casings.

B. Examine casing insulation materials and liners before installation. Reject casings that are wet, moisture damaged, or mold damaged.

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

### 3.2 INSTALLATION

A. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Equipment Mounting: Install HVAC casings on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

1. 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.
2. For supported casings, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install seismic restraints on casings. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Apply sealant to joints, connections, and mountings.

E. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Support casings on floor or foundation system. Secure and seal to base.

G. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

H. Align casings accurately at connections, with 1/8-inch misalignment tolerance and with smooth interior surfaces.

### 3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual."
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.

B. HVAC casings will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 233119
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Backdraft dampers.
   2. Pressure relief dampers.
   3. Barometric relief dampers.
   5. Control dampers.
   6. Fire dampers.
   7. Smoke dampers.
   8. Combination fire and smoke dampers.
   10. Turning vanes.
   11. Remote damper operators.
   12. Duct-mounted access doors.
   13. Flexible connectors.
   14. Flexible ducts.
   15. Duct accessory hardware.

B. Related Requirements:
   1. Division 23 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
   2. Division 23 “Diffusers, Registers and Grilles”.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, pressure relief-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION


B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653.

   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.
B. Aluminum Sheets: Comply with **ASTM B 209**, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.


D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, **1/4-inch** minimum diameter for lengths **36 inches** or less; **3/8-inch** minimum diameter for lengths longer than **36 inches**.

### 2.3 BACKDRAFT DAMPERS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Greenheck Fan Corporation.
3. Nailor Industries Inc.
4. Potorff.
5. Ruskin Company.
6. United Enertech

B. Function:
1. Designed to allow airflow in one direction and prevent reverse airflow.
2. Keeps outside air out of the space by sensing and closing against mass flow.

C. Description:
1. Gravity balanced.

D. Maximum Air Velocity:
   1. **1000 fpm**

E. Maximum System Pressure:
   1. **3-inch wg**.

F. Frame: Hat-shaped, with welded corners or mechanically attached and mounting flange:
   1. **16GA 0.063-inch- thick extruded aluminum**.

G. Blades: Multiple single-piece blades, maximum **6-inch** width noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges:
   1. Center pivoted: **16GA 0.050-inch- thick aluminum sheet**.

H. Blade Action: Parallel.

I. Blade Seals: Mechanically locked.
   1. Neoprene.

J. Blade Axles: **0.20 inch** diameter:
   1. Material: **Nonferrous metal**.
   2. 

K. Tie Bars and Brackets:
   1. **Aluminum**.
L. Return Spring: Adjustable tension.

M. Bearings:
   1. Synthetic pivot bushings.

N. Accessories.
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Counterweights and spring-assist kits for vertical airflow installations.
      a. Sleeve Thickness: 20 gage minimum.
      b. Sleeve Length: 6 inches minimum.
   4. Screen Mounting: Rear mounted.
   5. Screen Material:
      a. Aluminum.
   6. Screen Type:
      a. Bird
   7. 90-degree stops.

2.4 PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a division of Mestek, Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Pottorf.
   5. Ruskin Company.

B. Function:
   1. Provide component designed to protect HVAC systems by relieving air pressure from within a space that is beyond a pre-determined limit.
   2. To automatically begin to open at a pre-set pressure difference above maximum system pressure.
   3. Internally self-controlled with system pressure utilizing adjustable arms and weights.
   4. Self-actuated with system pressure utilizing adjustable arms and weights.
   5. Employs blade counterbalancing.
   6. Automatically closes and re-sets when pressures return to normal conditions.

C. Air Velocity:
   1. 3900 fpm.

D. Maximum System Pressure (MSP):
   1. 5-inch wg.
   2. 4-inch wg.

E. Differential Pressure Preset above MSP:
   1. 1-inch wg.

F. Maximum Damper Pressure Limit:
   1. 5.0-inch wg.
G. Frame Material: Flanged Channel:
   1. **14GA 0.079-inch- thick galvanized steel.**

H. Frame Depth: **8-inch-** minimum.

I. Blades:
   1. Material:
      a. **16GA 0.063-inch-formed galvanized steel.**
   2. Type:
      a. **Formed Sheetmetal.**
   3. Blade-stop:
      a. **With stop.**

J. Blade Action: **Parallel.**

K. Blade Seals:
   1. **Thermo Plastic Elastomer.**

L. Blade Axles:
   1. Material:
      a. **Plated steel.**
   2. Diameter: **0.375 inch.**

M. Linkage:
   1. **External heavy duty type with galvanized steel clevis arms and plated steel tie bars & pivot pins with nylon pivot bearings.**

N. Bearings:
   1. **Galvanized Steel ball.**

2.5 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a division of Mestek, Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Pottorff.
   5. Ruskin Company.

B. Function:
   1. Senses and compares outdoor ambient and indoor pressures.
   2. Allows any higher pressure indoor air to escape.

C. Description: Suitable for horizontal or vertical mounting.

D. Maximum Air Velocity:
   1. **1000 fpm**

E. Maximum System Pressure:
   1. **3-inch wg**
F. Frame: Hat-shaped, with welded corners or mechanically attached and mounting flange.
   1. 13GA 0.094-inch thick, galvanized sheet steel.

G. Blades: Multiple:
   1. 16GA 0.050-inch thick aluminum sheet.
   3. Action: Parallel.
   5. Pivot:
      a. Eccentric.

H. Blade Seals:
   1. Neoprene

I. Blade Axles:
   1. Galvanized steel

J. Tie Bars and Brackets: Rattle free with 90-degree stop.
   1. Material:
      a. Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings:
   1. Synthetic

2.6 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
         a. American Warming and Ventilating; a division of Mestek, Inc.
         b. McGill AirFlow LLC.
         c. Nailor Industries Inc.
         d. Pottorff.
         e. Ruskin Company.
         f. United Enertech
   2. Standard leakage rating, with linkage outside airstream.
   3. Suitable for horizontal or vertical applications.
   4. Frames: Hat-shaped, Mitered and welded corners. Flanges for attaching to walls and
      flangeless frames for installing in ducts.
      a. 16GA 0.064-inch thick, galvanized sheet steel.
   5. Blades:
      a. Multiple or single blade. Parallel- or opposed-blade design. Stiffened damper
         blades for stability.
      b. Material:
         1) Galvanized steel, 16GA 0.064 inch thick.
   6. Blade Axles:
a. **Nonferrous metal**
b. Shall extend full length of damper blades in ducts with pressure classes of 3-inch wg or more.

7. Bearings:
a. Material:
   1) **Molded synthetic.**
b. Bearings at both ends of damper operating shafts in ducts with pressure classes of 3-inch wg or more.

8. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. McGill AirFlow LLC.
   c. Nailor Industries Inc.
   d. Pottorf.
   e. Ruskin Company.
   f. United Enertech

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with **linkage outside airstream**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:
a. Frame: Hat-shaped,
   1) **16GA 0.064-inch** thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Material:
      1) **Galvanized, roll-formed steel, 16GA 0.064 inch thick.**

7. Blade Axles:
   a. **Nonferrous metal.**

8. Bearings:
   a. **Molded synthetic.**
   b. Dampers in ducts with pressure classes of 3-inch wg or more shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals:
   a. **Neoprene.**
10. Jamb Seals: Cambered **Stainless steel** or **aluminum.**
11. Tie Bars and Brackets: **Galvanized steel** or **aluminum.**
12. Accessories:
a. Include locking device to hold single-blade dampers in a fixed position without vibration.

C. Jackshaft:
   1. Size:
      a. 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.

2.7 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Potterff.
   3. Ruskin Company.
   4. Young Regulator Company.
   5. United Enertech

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA’s Certified Ratings Seal for both air performance and air leakage.

C. Frames:
   1. Section:
      a. Hat shaped.
   2. Material:
      a. 20 GA 0.40-inch-thick galvanized steel.
   3. Corners:

D. Blades: Multiple.
   1. Maximum blade width:
      a. 6 inches.
   2. Opposed-blade design.
   3. Material:
      a. Galvanized-steel.
   4. Thickness:
      a. 20 GA 0.40-inch-thick galvanized steel
   5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
      a. Closed-cell neoprene
E. Blade Axles:
   1. Section:
      a. 3/8-inch-square
   2. Material:
      a. Galvanized steel.
   3. Blade-linkage hardware:
      a. Zinc-plated steel and brass.
      b. Ends sealed against blade bearings:
   4. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:
   1. Type:
      a. Molded synthetic.
   2. Axles: Dampers in ducts with pressure classes of 3-inch wg or more shall have axles full length of damper blades.
   3. Bearings: Thrust bearings at each end of every blade. Bearings at both ends of each operating shaft.

2.8 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Arrow United Industries; a division of Mestek, Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Pottorff.
   5. Ruskin Company.
   6. United Enertech

B. Type:
   1. Dynamic.

C. Standard: Rated and labeled according to UL 555 by an NRTL.

D. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

E. Fire Rating:
   1. 1-1/2 hours.

F. Frame:
   1. Curtain type with blades outside airstream.
   2. Material:
      a. Fabricated with roll-formed galvanized steel; with mitered and interlocking corners.
      b. Thickness:
         1) 20GA-0.040-inch.-

G. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel. Length to suit application.
   1. Minimum Thickness:
      a. 18GA-0.05 inch, as indicated.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

H. Mounting Orientation: Vertical or horizontal as indicated.

I. Blades: Roll-formed, interlocking, galvanized sheet steel.
1. Thickness:
   a. 24GA-0.024-inch
2. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

J. Horizontal Dampers: Include blade lock and Type 301 constant force stainless-steel closure spring.

K. **Heat-Responsive Device**: Replaceable, 212 deg F rated, fusible links.

### 2.9 SMOKE DAMPERS

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

2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.
5. United Enertech

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

1. Type: Photoelectric.

D. Frame: Galvanized sheet steel. With or without mounting flange as required.

1. Thickness:
   a. **Hat-shaped, 16GA-0.064-inch.**
2. Corners:
   a. **Welded.**

E. Blades: Horizontal, galvanized sheet steel.

1. Section:
   a. **Roll-formed.**
2. Fit:
   a. **Interlocking.**
3. Thickness:
   a. **14GA-0.079-inch.**

F. Leakage:

1. **Class II.**

G. Seals:

1. Blade: Inflatable silicone fiberglass material to maintain smoke leakage rating to a minimum of 450 deg F.
H. Rated pressure and velocity to exceed design airflow conditions.

I. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
   1. Minimum **17-inches** long.
   2. Thickness:
      a. **0.05-inch**.

J. Damper Motors:
   1. Action:
      a. **Two-position**
   2. Mode: Fail close.

K. 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."
   1. Electrical Connection: **115 V, single phase, 60 Hz**.

L. Accessories:
   1. Auxiliary switches for signaling:
      a. **Position indication**.
   2. Test Switch type:
      a. **Momentary test switch**.
   3. Test Switch Mounting:
      a. **Damper**.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Nailor Industries Inc.
   3. Pottorff.
   4. Ruskin Company.
   5. United Enertech

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to **4-inch wg** static pressure class and minimum velocity of:
   1. **4000-fpm**

D. Fire Rating:
   1. **1-1/2 hours**.

E. Frame: Hat shaped, galvanized sheet steel. With or without mounting flange as required.
   1. Thickness:
      a. **16GA-0.064-inch**
   2. Corners:
      a. **Welded**.

F. **Heat-Responsive Device**: Replaceable, **212 deg F** rated, fusible links.
G. Blades: Horizontal, galvanized sheet steel.
   1. Type:
      a. Air-foil.
   2. Fit:
      a. Interlocking.
   3. Thickness:
      a. 0.063-inch-.

H. Leakage:
   1. Class I.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor
   application with factory-furnished silicone calking.
   1. Thickness:
      a. 18GA 0.05-inch-

K. Master control panel for use in dynamic smoke-management systems.

L. Damper Motors:
   1. Locate outside air stream unless otherwise indicated,
   2. Action:
      a. Two-position.
   3. Voltage: to match fire alarm system (coordinate).
   4. Listed: UL, as part of damper assembly.
   5. Outdoor Motors and Motors in Outside-Air Intakes:
      a. Gaskets: O-ring gaskets designed to make motors weatherproof.
         b. Internal heaters: Equip to permit normal operation at minus 40 deg F

M. 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."
   1. Electrical Connection: 115 V, single phase, 60 Hz.

N. Accessories:
   1. Auxiliary switches:
      a. Signaling.
      b. Position indication.
   2. Test Switch type:
      a. Momentary test switch.
   3. Test Switch Mounting:
      a. Damper.

2.11 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Industrial Acoustics Company.
   2. Ruskin Company.
   3. SEMCO Incorporated.
Logan City School District - Ellis Elementary School

B. General Requirements:
   1. Factory fabricated.
   2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:
   1. Rectangular straight with splitters or baffles.
   2. Round straight with center bodies or pods.
   3. Rectangular elbow with splitters or baffles.
   4. Round elbow with center bodies or pods.
   5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: Galvanized sheet steel.
   1. ASTM A 653:
      a. G60.
   2. Thickness:
      a. 22GA-0.034 inch.

E. Round Silencer Outer Casing: Galvanized sheet steel.
   1. ASTM A 653:
      a. G60.
   2. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 22GA-0.034 inch thick.
   3. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 20GA-0.040 inch thick.
   4. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 18GA-0.05 inch thick.
   5. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 16GA-0.064 inch thick.

F. Inner Casing and Baffles: Galvanized sheet metal with 1/8-inch- diameter perforations.
   1. ASTM A 653:
      a. G60.
   2. Thickness:
      a. 22GA-0.034 inch.

G. Special Construction:
   1. Suitable for outdoor use.
   2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:
   1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
   2. Dissipative or Film-lined type with fill material:
a. **Fill Material:** Inert and vermin-proof fibrous material, packed under not less than 15 percent compression
b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
c. Prohibited: Mineral wool will not be permitted as a substitute for glass fiber.

3. Lining:
   a. **Material:**
      1) **Tedlar**
   b. Prohibited: Mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints:
   a. **Lock formed and sealed.**
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.
4. Structural Criteria: The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gage.
5. Spot Welds: All spot welds shall be painted.

K. Accessories:

1. Integral [1-1/2] [3]-hour fire damper with access door. **Access door to be high transmission loss to match silencer.**
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.

### 2.12 TURNING VANES

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

1. METALAIRE, Inc.
2. SEMCO Incorporated.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Fabricate single blade vanes to comply with SMACNA’s “HVAC Duct Construction Standards-Metal and Flexible.”

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction:
1. **Single** wall

F. Vane Spacing:
1. 1-1/2” spacing between turning vanes
2. 3-1/4” spacing not allowed.

G. Vane Construction: Single wall for ducts up to 36 inches wide and additional bracing for larger dimensions.

2.13 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Pottorff.
   2. Ruskin Company; Tomkins PLC.
   3. Young Regulator Company.

B. Cable Type:
   1. Description: Cable system designed for remote manual damper adjustment.
   2. Tubing/Sheathing: Galvinsed, Brass, Copper or Aluminum.
   3. Cable: Stainless steel or Steel.
   4. Wall-Box Mounting: Coordinate with Architect.
   5. Wall-Box Cover-Plate Material: Coordinate with Architect.

C. Activated Electric Type:
   1. Description: Electrically activated zone control damper for remote adjustment. When an adjustment is needed the system is powered up.
   3. Portable 9 volt system. No field power requirement.
   4. Mounting: Recessed Wall Box or Diffuser or Hand Held.
   5. Wall-Box Cover Finish: Coordinate with Architect.
   6. Wall-Box Porting: 1 to 6 ports or more.

2.14 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. McGill AirFlow LLC.
   3. Pottorff.
   5. Ruskin Company

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:
      1) Hinges: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches, provide outside and inside handles:
      1) Hinges: Three hinges and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches, provide outside and inside handles:
      1) Hinges: Continuous and two compression latches with outside and inside handles.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Ventfabs, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a wide fabric strip attached to two narrower metal strips. Provide strips of metal compatible with connected ducts.
   1. Wide Strip:
      a. 3-1/2 inches.
   2. Narrow Strips:
      a. 0.028-inch-thick, galvanized sheet steel.

   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

   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**.

### 2.16 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Themaflex

B. Ducts shall conform to the requirements for Class I connectors when tested in accordance with "Standard for Factory Made Air Ducts Materials and Air Duct Connectors" (UL 181).

C. Ducts shall also pass the 15 minute U.L. flame penetration test as specified in the UL 181 Standard.

D. Insulated, Flexible Duct: Two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

   1. Pressure Rating: **10-inch wg** positive and **1.0-inch wg** negative.
   2. Maximum Air Velocity: **4000 fpm**.
   3. Temperature Range: **Minus 10 to plus 160 deg F**.
   4. Insulation R-value: **Comply with ASHRAE/IESNA 90.1**.

E. Flexible Duct Connectors:

   1. Clamps: in sizes **3 through 18 inches**, to suit duct size.

### 2.17 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.

C. Splitter Damper Accessories: Zinc-plated damper blade bracket; **1/4-inch**, zinc-plated operating rod; and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes **3 to 18 inches** to suit duct size.

### 2.22 HIGH EFFICIENCY TAKE-OFFS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Air-Rite
2. Hercules Industries
3. Sheet Metal Connectors, Inc.
4. Spiral Manufacturing Co. Inc.
5. Ferguson

B. Materials:

1. 24 gauge galvanized sheet metal meeting ASTM A653 and A924

C. Take-off shall meet SMACNA third edition Section 4.8 figure 4.6 - 45 degree entry.

D. Rectangular opening with flanged sides on all sides. Complete with closed cell neoprene gasket to provide a tight seal.

PART 3 - EXECUTION

3.1 INSTALLATION

General

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. Use the Remote Damper Operator when they are called out on the drawings or when the damper cannot be easily accessed.

D. Install high efficiency take-off on all branch duct take-offs. Provide take-off with balancing damper as shown on drawings. Spin-in fittings are not allowed.

Flexible Ducts / Flexible Duct Connectors

E. Install flexible connectors to connect ducts to equipment.

F. Flexible duct connections from the main trunk ducts to diffuser boots shall be furnished and installed as shown on the drawings. Flexible ductwork shall only be used as indicated on the drawings.

G. Where flexible duct is indicated, use insulated flexible duct for supply air return and exhaust air.

H. Flexible ductwork shall be run in straight lengths.

I. Provide support in flexible duct every three feet.

J. Flexible ducts shall have compression fittings on both ends.
K. Flexible ductwork is not allowed to bend 90 degrees. If a bend is needed use sheet-metal hard elbows. Hard turns, offsets, or kinks will not be allowed.

L. Flexible ducts shall connect to trunk duct with high efficiency takeoffs.

M. Connect flexible ducts to metal ducts with **draw bands**.

N. Connect ducts to duct silencers:
   1. With flexible duct connectors.

O. Connect terminal units to supply ducts:
   1. With maximum 12-inch lengths of flexible duct.

P. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to ducts:
   1. With maximum 60-inch lengths of flexible duct clamped or strapped in place.

**Backdraft/Control/Pressure Relief Dampers**

R. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

S. Install pressure relief damper immediately upstream of main fire damper.

**Volume Damper**

T. 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.

U. Set dampers to fully open position before testing, adjusting, and balancing. Exception: Pressure relief damper.

V. A balance damper with locking quadrant will be provided downstream of take-off from trunk duct.

**Fans And Test Holes**

W. For fans developing static pressures of **5-inch wg** and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

X. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of **1/4-inch** movement during start and stop of fans.

Y. Install duct test holes where required for testing and balancing purposes.

Z. Install test holes at fan inlets and outlets and elsewhere as indicated.

**FIRE, SMOKE AND FIRE-SMOKE DAMPERS**
AA. Install fire and smoke dampers according to UL listing.
   1. Install fusible links in fire dampers.

BB. For round ductwork 24-inch and smaller a true round fire damper with the same rating may be used.

**Access Doors**

CC. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On upstream side of duct coils.
2. **Upstream** from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be **standard 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** from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

DD. Install access doors with swing against duct static pressure.

EE. Access Door Sizes:

1. One-Hand or Inspection Access: **8 by 5 inches**.
2. Two-Hand Access: **12 by 6 inches**.
3. Head and Hand Access: **18 by 10 inches**.
4. Head and Shoulders Access: **21 by 14 inches**.
5. Body Access: **25 by 14 inches**.

FF. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

### 3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.
3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

END OF SECTION 233300
SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Centrifugal roof ventilators.
   2. Axial roof ventilators.

1.3 PERFORMANCE REQUIREMENTS
A. Project Altitude: Base fan-performance ratings on:
   1. Actual Project site elevations.
B. Operating Limits: Classify according to AMCA 99.
C. Fan Schedule: Fan characteristics and performance data are described in an equipment schedule on the drawings including:
   1. Fan arrangement with wheel configuration, inlet and discharge configurations, and required accessories.
   2. Capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, shipping weights, operating weights, operating characteristics, and furnished specialties and accessories. Also include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
a. Detail all wiring systems and differentiate clearly between manufacturer-installed and field-installed wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control Reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

1.8 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Power ventilator electrical components shall comply with applicable NEMA standards.

D. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

E. TUV Certified: High Volume low speed fan shall comply with UL 507

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.
C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PRODUCTS FURNISHED BUT NOT INSTALLED

A. Products furnished, but not installed, under this Section include roof curbs for roof-mounted exhaust fans. Roof curbs to be installed by Division 07, section “Roof Accessories”.

2.2 CENTRIFUGAL ROOF VENTILATORS

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

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Twin City.

B. Housing: Removable: Square, one-piece, aluminum base with vent cone.

1. Spun-aluminum, dome top and outlet baffle.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels:
1. Aluminum hub and wheel with backward-inclined blades.
2. Spark-Resistant Construction: AMCA 99, Type A

D. Direct-Drive Units: Motor mounted outside of airstream within fan housing.

E. Belt-Driven Units: Motor mounted on adjustable base, adjustable sheaves and with motor and belts within fan housing.

F. Accessories:
1. Disconnect Switch: Nonfusible type:
   a. Thermal-overload protection; factory wired through an internal aluminum conduit.
      1) Mounted inside fan housing.
2. Bird Screens: Removable, 1/2-inch mesh:
   a. Aluminum wire.
3. Dampers:
   a. Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   b. Motorized parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base. Provide neoprene gasket between fan base and curb to reduce sound transmission.
1. Configuration:
   a. **Self-flashing without a cant strip, with mounting flange.**

2. Overall Height:
   a. **14 inches.**
   b. **18 inches.**

**H. KITCHEN CENTRIFUGAL UPBLAST EXHAUSTERS**
1. Spark-Resistant Construction: AMCA 99, Type A
2. Refer to Division 23 Section "Motors" for general requirements for factory-installed motors.

**2.3 MOTORS**
A. 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."

   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. Enclosure Type: Totally enclosed;
   1. **Fan cooled**

**2.4 FACTORY FINISH**
A. Metal Parts: All assembly parts shall be protected from rust and corrosion.
   1. Stainless steel, aluminum, and other non-corroding materials require no protective finish.
   2. Non-galvanized sheet metal parts shall be prime coated or powder coated before final assembly.
   3. Prime coated parts shall receive baked enamel finish coat after assembly.

**2.5 SOURCE QUALITY CONTROL**
A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**
A. Examine areas and conditions for compliance with requirements of installation tolerances and other conditions affecting performance of the power ventilators. Do not proceed with installation until unsatisfactory conditions have been corrected.
3.2 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions by field measurements. Verify clearances.

B. Do not operate fans until ductwork is clean, filters are in place, bearings are lubricated, and fans have been commissioned.

3.3 INSTALLATION

A. Install power ventilators level and plumb according to manufacturer's written instructions.

B. Base Mounted Equipment:
   1. Install power ventilators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in:
      a. Division 33 "Cast-in-Place Concrete."

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. **Support Steel**: Support suspended units from structure using threaded steel as specified in Division 23 "Vibration and Seismic Controls for HVAC."

F. Label units according to requirements specified in Division 23 "Identification for HVAC Piping and Equipment."

G. Install power ventilators with factory recommended and code required clearances for service and maintenance.

3.4 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."
   1. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

D. Connect wiring according to Division 26 "Low-Voltage Electrical Power Conductors and Cables."
   1. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 23 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.7 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction debris. Vacuum clean fan wheel and cabinet.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

C. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

D. Demonstrate operation of power ventilators. Conduct walking tour of the Project. Briefly identify location and describe function, operation, and maintenance of each power ventilator.

END OF SECTION 233423
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Shutoff, single-duct air terminal units.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
   1. Air terminal units.
   2. Liners and adhesives.
   3. Sealants and gaskets.
B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams:
      a. For power, signal, and control wiring.
      b. Differentiate between manufacturer-installed and field-installed wiring.
   3. Hangers and supports, including methods for duct and building attachment and vibration isolation.
C. Delegated-Design Submittal:
   1. Materials, fabrication, assembly, and spacing of hangers and supports.
   2. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Air terminal units shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fan-Powered-Unit Filters: Furnish one spare filter for each filter installed.

1.8 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

B. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

C. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

D. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

E. Comply with NFPA 70 for electrical components and installation.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

2.2 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.

2.3 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Anemostat Products; a Mestek Company.
2. Carnes.
3. Environmental Technologies, Inc.
5. METALAIRE, Inc.
6. Nailor Industries Inc.
7. Price Industries.
8. Titus.
9. Trox USA Inc.; a subsidiary of the TROX GROUP.
10. Tuttle & Bailey.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel, single wall.

1. Casing Lining: Adhesive attached, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   a. Lining thickness:
      1) 1/2-inch-
   b. Cover liner with nonporous foil.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
5. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage:
   a. ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position:

E. Hydronic 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.

L. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, spring return open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume 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 specified in Section 230900 "Instrumentation and Control for HVAC."

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

F. Control Sequence:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Galvanized steel complying with ASTM A 603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.
1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.

PART 3 - EXECUTION

3.1 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. Install discharge air temperature sensors at the outlet of each Air Terminal Unit.

E. Connect ductwork to air terminals according to Division 23 ductwork Sections.

F. Comply with SEI/ASCE 7 and with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

G. For Diffuser Type Air Terminal Units, provide and install all necessary control wiring and control voltage transformer. See drawings AND schedules for additional information.

3.2 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 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.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.
B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Section 233113 "Metal Ducts."

D. Electrically ground all equipment:
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

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

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

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. After installing 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.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Cleaning:
   1. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to:
   a. Manufacturer's written instructions.
   b. Construction documents.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Review data in the maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

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

1.2 SUMMARY
A. This section includes ceiling- and wall-mounted diffusers, registers, and grilles.
B. Related Sections:
   1. Section 233714 "Fixed Louvers" for fixed and louvers and wall vents, whether or not they are connected to ducts.
   2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.
B. Source quality-control reports.
1.5 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated.


PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Air Factors
2. Carnes.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
7. Titus.
8. Tuttle & Bailey.
10. Trox.

2.2 REGISTERS, GRILLES, & DIFFUSERS

A. General: The frames for all registers, grilles, and diffusers shall match type of ceiling where they are to be installed. Special frames shall be provided for narrow T-bar ceilings. Refer to reflected ceiling plan and other specification divisions for ceiling type. See drawings AND schedules for additional information.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, coordination drawings, original design, and referenced standards.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.4 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 233713
SECTION 233714 - FIXED LOUVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Fixed, extruded-aluminum louvers.

B. Related Requirements:
   1. Section 099113 "Exterior Painting" for field painting louvers.

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades (i.e., the axes of the blades are horizontal).

C. Vertical Louver: Louver with vertical blades (i.e., the axes of the blades are vertical).

D. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
   1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
   2. Show mullion profiles and locations.

C. Samples: For each type of metal finish required.
1.5 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Louvers, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. Design Spectral Response Acceleration at Short Periods: Per the structural drawings and specifications.
   2. Component Importance Factor: 1.0.

B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.


2.3 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Drainable-Blade Louver:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Airolite Company, LLC (The).
b. Pottorf.
c. Ruskin Company; Tomkins PLC.

2. Louver Performance Ratings:
   a. Free Area: Not less than **8.5 sq. ft.** for 48-inch- wide by 48-inch- high louver.
   b. Point of Beginning Water Penetration: Not less than **1250 fpm.**
   c. Air Performance – **intake:** Not more than **0.10-inch wg** static pressure drop at 900-fpm free-area velocity.
   d. Air Performance – **exhaust:** Not more than **0.15-inch wg** static pressure drop at 1000-fpm free-area velocity.

3. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

### 2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.
   1. Screen Location for Fixed Louvers: Interior face.
   2. Screening Type: **Bird screening.**

B. Secure screen frames to louver frames with **machine screws with heads finished to match louver,** spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
   1. Metal: Same type and form of metal as indicated for louver to which screens are attached. **Reinforce extruded-aluminum screen frames at corners with clips.**
   2. Finish: Same finish as louver frames to which louver screens are attached
   3. Type: **Rewirable frames with a driven spline or insert**

D. Louver Screening for Aluminum Louvers:

### 2.5 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.
   1. Contractor shall use **or hex-head or** screws for exposed fasteners screws for exposed fasteners unless otherwise indicated.
   2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   3. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
2.6 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: **Channel** unless otherwise indicated.

D. Include supports, anchorages, and accessories required for complete assembly.

E. Join frame members to each other and to fixed louver blades with fillet welds **concealed from view** unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.7 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. Color Anodic Finish: AAMA 611, or thicker.

1. Color: **As selected by Architect from full range of industry colors and color densities.**

C. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: **As selected by Architect from manufacturer's full range**

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.
3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weather-tight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weather-tight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

   1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 233714
SECTION 235100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL.

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Listed double-wall vents.

2. POSITIVE PRESSURE FLUES
   a. Listed: Double-wall vents.
   b. Field-fabricated metal breechings.

3. CATEGORY IV, CONDENSING BOILERS, SPECIAL GAS VENTS
   a. Listed: Double-wall vents.
   b. This section specifies:
      1) Category IV vents/chimneys.
      2) Special Gas Units.
      3) Condensing Boilers – positive pressure.

B. Related Sections include the following:

1. Section 235113 "Draft Control Devices" for induced-draft and mechanical fans and for motorized and barometric dampers.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Chimney liners.
2. Type B and BW vents.
3. Type L vents.
4. Special gas vents. (Category IV, Condensing Boilers, Special Gas Vents).
7. Refractory-lined metal breechings and chimneys.
8. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.

2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Manufacturer **Seismic** Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand **seismic** forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the **seismic** forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the **seismic** forces specified and the unit will be fully operational after the **seismic** event."

2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

C. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.


C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

D. Verification: Flue type to be verified by the boiler manufacturer of the submitted boiler.

1.6 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in **Division 07**.
1.7 **WARRANTY**

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: To cover the following number of years from date of Substantial Completion:
   a. 10 years.

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PART 2 - PRODUCTS

2.1 **LISTED TYPE B AND BW VENTS**

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

1. Ampco.
2. Cleaver-Brooks.
3. Metal-Fab, Inc.
4. Schebler Co. (The).
5. Selkirk Corporation; Selkirk Metalbestos and Air Mate.
6. Simpson Dura-Vent Co., Inc.
7. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B, or 550 deg F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.

D. Inner Shell:  
   1. ASTM B 209, Type 1100 aluminum

E. Outer Jacket:  
   1. Galvanized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: Antibackdraft.

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2.2 **LISTED SPECIAL GAS VENTS (POSITIVE PRESSURE FLUES)**

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. Duravent
2. Heat-Fab, Inc.
3. Z-Flex; a division of the Novaflex Group.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Vent shall be factory-built special gas type, double wall, engineered and designed for use on Category IV appliances, or as specified by the equipment manufacturer.

D. Maximum continuous flue gas temperature not to exceed 550° F for gas burning appliances.

E. Construction: Inner conduit and outer wall casing shall be constructed with a one-inch air space between them and in such a fashion that prevents cross-alloy contamination. Optional 1” fiber insulation is available to maintain higher flue temperatures, but does not reduce clearances beyond the standard clearances tested for 1” air space model CI Plus.

F. Inner Shell: Vent shall be constructed with an inner conduit constructed of ASTM A 959, Type 29-4C or 2904 superferritic stainless steel with a minimum thickness of 0.015” for diameters of 3” to 8”, 0.20” for diameters of 10” to 16”, 0.025 for diameters 18” to 24”, and 0.035” for 26” and greater.

G. Outer Jacket: The outer wall casing shall be constructed of 430 stainless steel that shall not require additional surface preparation, such as painting, in order to withstand the outdoors or high humidity environments.

H. The joint closure shall be an inner wall mechanical locking strap design. Joints shall not use screws or fasteners that penetrate the inner conduit.

I. General Electric RTV105 or Down Corning 736 high temperature sealant shall be used to seal all joints on systems where the maximum flue gas temperature will not exceed 550° F or a factory installed 550° F compatible silicone rubber gasket shall be used to seal joints.

J. Vent shall be listed for an internal static pressure of 15” w.g. and tested to 37” w.g.

K. Vent shall be constructed with a factory installed gasket used to seal the joint for diameters 4” to 16”. Use of gasket lube, available from the factory, should be used for maximizing gasket life and ease of installation. For diameters 18” to 32”, joints shall be sealed with factory supplied RTV sealant.

L. Tees and elbows shall provide a pressure drop less than 15 feet equivalent horizontal vent.

M. Fittings that increase or decrease vent diameter shall be asymmetric in construction with a flat wall that maintains a straight line with adjoin parts in order to facilitate the unobstructed flow of all condensate.

N. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
O. All parts shall be compatible with other single wall and double wall products of the same manufacturer.

P. System is to be sized in accordance with the appliance manufacturer’s specifications, NFPA 54 National Fuel Gas Code (ANSI Z223.1), ASHREA recommendations, and other applicable codes.

2.3 FIELD-FABRICATED METAL BREECHINGS AND CHIMNEYS

A. Fabricate freestanding chimneys according to SMACNA’s “Guide for Steel Stack Design and Construction.” (See Drawings for Dimensions).

B. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 1.069 Sq. Ft. or 14 Inches in Diameter: 0.053 inch.
2. Up to 1.396 Sq. Ft. or 16 Inches in Diameter: 0.067 inch.
3. Up to 1.764 Sq. Ft. or 18 Inches in Diameter: 0.093 inch.
4. Larger Than Above: 0.123 inch.

C. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 6 Inches in Diameter: 0.019 inch.
2. Up to 10 Inches in Diameter: 0.024 inch.
3. Up to 16 Inches in Diameter: 0.029 inch.
4. Larger Than Above: 0.056 inch.

D. Fabricate chimneys and vent connectors from ASTM B 209, Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:

1. Aluminum: 0.027 inch.
2. Stainless Steel: 0.012 inch.

E. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

A. Fabricate engine exhaust:

1. From ASTM A 53, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, pipe;
   a. Schedule 40.
2. With welded joints and carbon-steel fittings and flanges.
3. With wrought Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.

2.4 GUYING AND BRACING MATERIALS

A. Cable: Three galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch.
3. For ID Sizes 18 to 24 Inches: 3/8 inch.
4. For ID Sizes 27 to 30 Inches: 7/16 inch.
5. For ID Sizes 33 to 36 Inches: 1/2 inch.
6. For ID Sizes 39 to 48 Inches: 9/16 inch.
7. For ID Sizes 51 to 60 Inches: 5/8 inch.

B. Pipe: Two galvanized steel, NPS 1-1/4.

C. Angle Iron: Two galvanized steel, 2 by 2 by 0.25 inch.

EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

3.2 APPLICATION

A. Listed Type B and BW Vents: Vents for certified gas appliances.

B. Listed Special Gas Vent: Condensing gas appliances.


D. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

E. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.
3.4 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS AND CHIMNEYS

A. Suspend breechings and chimneys independent of their appliance connections.

B. Install, support, and restrain according to seismic requirements.

C. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch misalignment tolerance.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 235100
SECTION 23 5216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes natural gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

B. Division 23 shall arrange and pay for State of Utah Boiler inspection and Inspection Certificate.

1.3 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, and Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to Authority Having Jurisdiction (AHJ).

F. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.

2. Include rated capacities, operating characteristics, and furnished specialties and accessories. Capacity values shall be de-rated based on the project altitude.
B. Shop Drawings: For boilers, boiler trim, and accessories.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include boiler flue and combustion air duct schematic drawing showing all flue and duct sizes, lengths, fittings and terminations based on field measurement of actual conditions.

C. Draft Analysis: Factory boiler flue and combustion air duct Draft Analysis based on the shop drawings using actual sizes, lengths and fittings; and the project altitude.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on:
      a. Test of assembled components by a nationally recognized testing standard procedure, such as ICC-ES AC 156. The substantiated seismic design capacities shall exceed the seismic demand determined by Section 13.3 of ASCE 7.
      b. An engineering analysis conforming to the requirements of Chapter 13 of ASCE 7.
      c. Experience data conforming to a nationally recognized procedure. The substantiated seismic design capacities shall exceed the seismic demands determined by Section 13.3 of ASCE 7.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.
   1. Factory burner and hydrostat tests.
   2. Factory inspections and testing done in accordance with 2010 ASME Boiler and Pressure Vessel Code

C. Field quality-control reports.
   1. Start checklists and testing performed by Factory-Authorized Service Representative.
   2. Performance testing performed by Factory-Authorized Service Representative.

D. Sample Warranty: For special warranty.

E. Other Informational Submittals:
   1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
1.6 **CLOSEOUT SUBMITTALS**

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.7 **WARRANTY**

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:
   a. Leakage and Materials: ten (10) years from date of Substantial Completion.
   b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Non-prorated for five (5) years from date of Substantial Completion.

**PART 2 - PRODUCTS**

2.1 **MANUFACTURERS**

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

1. AERCO International, Benchmark Series.
2. Fulton, Vantage Series (2.0 to 6.0 MMBH)
3. Lochinvar, Crest Series.

2.2 **FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS**

A. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

B. Heat Exchanger: Stainless Steel, corrosion-resistant combustion chamber.

C. Burner: Natural gas, forced draft.

D. Blower: Centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   a. 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. Gas Train: Control devices and modulating control sequence shall comply with ASME CSD-1 requirements.
F. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

G. Casing:
   1. Jacket: Sheet metal, with snap-in or interlocking closures.
   2. Control Compartment Enclosures: NEMA 250, Type 1A.
   4. Insulation: Minimum 2-inch thick, polyurethane-foam insulation surrounding the heat exchanger.

H. Capacities and Characteristics:
   1. Comply with the pressures, temperatures, flow rates, efficiencies and electrical characteristics as scheduled in the project Plans.

2.3 TRIM

A. Include devices sized to comply with ASME B31.1.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated, pressure rating as scheduled on Drawings.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS-3/4 ball valve with hose-end and cap.

G. Condensate Trap: Provided by manufacturer.

H. Condensate Neutralization Tank: Provide by manufacturer with limestone chips.

2.4 CONTROLS

A. Refer to Section 230900 "Building Automation System" and Section 230993 "Sequence of Operations."

B. Boiler Management System: microprocessor based complete integrated system to control operations and energy input into the boiler plant. The boiler management system may be integrated into each boiler OR may be a standalone controller mounted separate from the boilers.

   1. Sequencing Capability: 2 to 8 boilers to meet system load.
   2. Boiler Operation: Automatically rotate lead/lag among the boilers on system; monitor run hours per boiler; and balance load to maintain equalize boiler run hours.
   3. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
5. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
6. Control wiring: Control wiring per the manufacturer's written instructions shall be by the Controls Contractor, refer to Section 230900 "Building Automation System".

C. Building Automation System (BAS) Interface: Factory installed hardware and software to enable the BAS to remotely monitor, control, and display boiler status and alarms from a BAS operator workstation.

1. Hardwired Points:
   b. Control: Enable/disable operation and hot-water-supply temperature set-point adjustment (with 4-20 ma signal from the BAS).

2. Communication: LONworks or BACnet (ASHRAE 135)
3. Controlled Features:
   a. Alarms and alarm history.
   b. Monitored points displayed locally at boiler control panel shall be available through BAS.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Refer to "Special Gas Vent" requirements Section 235100 “Breechings, Chimneys, and Stacks”.

B. Kit: Complete Category IV (positive pressure, fully condensing) system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and neutralization tank, and sealant.

C. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.
2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations based on the provided equipment before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment bases. Concrete equipment bases shall comply with overall size, thickness, and edge distance for anchor bolts required in Section 230548 "Vibration and Seismic Controls" Submittal.

2. Equipment Bases: Comply with requirements specified in Section 033053 "Miscellaneous Cast-in-Place Concrete".

3. Vibration Isolation and Seismic Control: Comply with requirements specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.
3.3 CONNECTIONS

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

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

C. Install field-mounted equipment (condensate traps, condensate neutralization tanks, etc.) furnished with the boiler but factory mounted.

D. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve.

E. Connect piping to boilers mounted on vibration isolators, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

F. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

G. Connect hot-water piping to supply and return boiler tapings with shutoff valve and union or flange at each connection.

H. Install piping from safety relief valves to nearest floor drain.

I. Boiler Venting:
   1. Install flue venting kit and combustion-air intake.
   2. Connect full size to boiler connections.
   3. Comply with “Special Gas Vent” requirements in Section 235100 "Breechings, Chimney and Stacks”

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.

b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

D. Prepare written test and inspection reports, with findings and corrective actions. Submit written report to Architect.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose.

F. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine capacity and efficiency of boilers.

a. Test for full capacity.

4. Repeat tests until results comply with requirements indicated.

5. Provide analysis equipment required to determine performance.

6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.

7. Notify Architect 10 days minimum in advance of test dates.


3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing and preventive maintenance of boilers.

1. Review data in the Operation and Maintenance Manual. Refer to Division 1 Section “Contract Closeout”.

2. Schedule training with Owner through Architect with at least 10-days advance notice.

END OF SECTION 23 5216
SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes gasketed-plate heat exchangers.

1.3 DEFINITIONS
A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

1.5 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Tube-removal space.
   2. Structural members to which heat exchangers will be attached.
B. Source quality-control reports.
C. Field quality-control reports.
D. Sample Warranty: For manufacturer's warranty.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Plate, Domestic-Water Heat Exchangers:

1) Brazed-Plate Type: One year.
2) Plate-and-Frame Type: One year.

PART 2 - PRODUCTS

2.1 GASKETED-PLATE HEAT EXCHANGERS

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

1. Armstrong Pumps, Inc.
2. Delta T Heat Exchangers.
3. ITT Corporation.
5. TACO Incorporated.
6. Wessels
7. Kelvion

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: 0.031 inch thick before stamping; Type 304L stainless steel.

I. Gasket Materials: Nitrile rubber
   1. Glue: Chlorine free.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
   1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
   2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid stainless-steel removable shroud.

2.2 ACCESSORIES

A. Hangers and Supports:
   1. Custom, steel supports for mounting on:
      a. Floor.
   2. Ensure both horizontal and vertical support of heat exchanger by providing:
      a. Factory-fabricated steel supports.
   3. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Shroud:
   1. Steel sheet.

C. Miscellaneous Components for High-Temperature Hot-Water Unit: Control valve, valves, and piping.

D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping.

E. Pressure Relief Valves:
   1. Cast iron
   2. ASME rated and stamped.

2.3 SOURCE QUALITY CONTROL

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

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

3.2 GASKETED-PLATE HEAT-EXCHANGER INSTALLATION

A. Install gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

B. Install metal shroud over installed gasketed-plate heat exchanger according to manufacturer's written instructions.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other:
   1. Section 232113 "Hydronic Piping."
   2. Section 232116 "Hydronic Piping Specialties."
   3. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam and condensate piping specified in:
   1. Section 232213 "Steam and Condensate Heating Piping"
   2. Section 232216 "Steam and Condensate Piping Specialties."

C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

E. Install shutoff valves at heat-exchanger inlet and outlet connections.

F. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

G. Install vacuum breaker at heat-exchanger steam inlet connection.

H. Install hose end valve to drain shell.
I. Install thermometer on heat-exchanger and outlet piping, and install thermometer on heating-fluid outlet piping.

J. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

K. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

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

END OF SECTION 235700
SECTION 23 7313 - CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

   1. Custom indoor air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: For the project’s largest air handler, submit design calculations, signed by the manufacturer, to certify compliance with the Cabinet and Casing design requirements. See Part 2 of this Specification.

B. Air Leakage Performance: For the project's largest air handler that can be shipped to the job site as a single unit, factory Leak Test results signed by the manufacturer, to certify compliance with the Cabinet and Casing design requirements. See Part 2 of the Specification.

C. Sound Power Levels: Submit sound power level data (discharge opening, inlet opening and radiated through casing) for each air handling unit. The submittal shall include complete description of methods and procedures used to develop the sound power data.

D. Fan/Motor Assembly Balance and Vibration: All fan/motor assemblies shall be factory tested units at design RPM. Maximum vibration shall be within the limits of ANSI/AMCA 205-05 (R2012) Fan Application Category BV-4 Balance Quality Grade 2.5. A certificate of compliance signed by the manufacturer shall be attached to each fan assembly at the factory and incorporated into the Operation and Maintenance Manuals.

E. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified".

1.4 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

   1. Unit dimensions and weight.
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fans:
a. AMCA 210 Certified fan-performance curves with system operating conditions indicated.
b. AMCA 311 Certified fan-sound power ratings.
c. Fan construction and accessories.
d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Drain Pan ASHRAE 62.1 factory test certification.
6. Dampers, including housings, linkages, and operators.
7. Filters with performance characteristics.
8. Casing design calculations for project’s largest air handling unit.
9. Factory Air leakage test results for project largest air handling unit.
10. Sound power level data for each air handling unit.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
   2. Support location, type, and weight.
   3. Field measurements.

B. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on:
      a. Test of assembled components by a nationally recognized testing standard procedure, such as ICC-ES AC 156. The substantiated seismic design capacities shall exceed the seismic demand determined by Section 13.3 of ASCE 7.
      b. An engineering analysis conforming to the requirements of Chapter 13 of ASCE 7.
      c. Experience data conforming to a nationally recognized procedure. The substantiated seismic design capacities shall exceed the seismic demands determined by Section 13.3 of ASCE 7.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.
1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish additional materials that match products as installed in the delivered air handlers and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set; for each air-handling unit and to be installed by the Contractor at Substantial Completion.
2. Gaskets: One set for each access door.

1.8 QUALITY ASSURANCE

A. ETL Labeling: List and label units by ETL. If ETL listing and labeling is not available, UL listing and labeling will be acceptable. No other agency listings or labels can be substituted without detailed submittal, review and acceptance in writing. If any is delivered to the site without such label, the manufacturer shall pay all costs to have ETL or UL field certification accomplished and the labels registered and field applied with a field certification report prepared by either agency.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling unit components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."


L. Manufacturers Qualifications: Provide Air Handling units and major components which are products of Manufacturing Firms regularly engaged in manufacture of equipment with characteristics and capacities as scheduled and whose products have been in satisfactory and similar service for not less than 3-years and must have a minimum of ten (10) working installations that have been in operation for a least 2-years. Manufacturer must have in-house engineering support.
1.9 COORDINATION

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

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

C. Coordinate anchor bolts, concrete base thickness and bolt edge setback required by Section 230248 Vibration Isolation and Seismic Restraint.

1.10 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Air Handlers
   a. Climate Craft.
   b. Energy Labs.
   c. Governair.
   d. Haakon.
   e. Huntair.
   f. Innovent
   g. Temtrol.
   h. Unitech.
   i. York Custom.

2. Fan Array Assemblies
   a. Climate Craft.
   d. Huntair.
   f. Twin City.
   g. Inovent

3. Control Dampers
   a. Ruskin Model CD50.
   b. Greenheck Model VCD-43.
   c. Tamco Series 1000.
2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:


2. Casing panels: Self-supporting and capable of withstanding 133 percent of design static pressure as scheduled on the Plans, without panel joints exceeding a deflection of L/200 where “L” is the unsupported span length within the completed Casing. For the project’s largest air handler, submit design calculations, signed by the manufacturer, to certify compliance with the Cabinet and Casing design requirements.

3. Casing leakage: Not to exceed 1 percent of the design flow rate at 133 percent of the design static pressure as scheduled on the Plans. For the project’s largest air handler that can be shipped to the job site as a single unit, submit factory Leak Test results signed by the manufacturer, to certify compliance with the Cabinet and Casing design requirements. If no air handlers can be shipped as single units, the largest air handler shall be factory assembled and factory leak tested prior disassembly and shipment. If lead-time or some other circumstance does not allow for factory leak testing then a field leak test shall be conducted at no additional expense to the project. Submit Field Leak Test results signed by the manufacturer to certify compliance with the Cabinet and Casing design requirements.

4. Sealing: Seal all joints with water-resistant sealant.

5. Finish: Manufacturer’s standard finish (interior and exterior) is acceptable for indoor air handlers, unless otherwise specified.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Casing Insulation:

1. Materials: ASTM C 1071, Type II.

2. Location and Application: Completely encased between outside and inside casing. A finish bead of caulking will be applied inner liner panel seams to completely encapsulate the insulation.

C. Base Construction:

1. Unit Base: Constructed of structural steel tube or channel shapes framing around the entire perimeter of the unit and provided with intermediate structural tubing or channel shapes as required to support the internal components. All tubing and channel joints shall be solid welded. Base shall be provided with removable lifting lugs minimum (4) per section, located to assure uniform loading.

2. Unit Base Floor: Constructed with minimum 12 gauge steel floor with continuously welded seams and the manufacturer’s standard finish. Floor shall be welded to unit base perimeter and intermediate structural tubing or channel shapes.


4. Base Floor Openings: Opening in the floor greater than one square foot, including openings with dampers, covered with a removable steel grate, bolted in place. Manufacturer’s standard finish for steel floor grates is acceptable. Grates shall be capable of supporting minimum 300 pounds with grate bars spaced to prevent personnel and large objects from fall into duct or space below air handler.

5. Base Finish, Indoor Units: Manufacturer’s standard finish is acceptable for indoor air handling units.

D. Roof Construction for Outdoor Units:
1. Construction: Weather-Proof, raised standing seams with mechanically formed cleat enclosing standing seam at each roof panel-to-panel joint.
2. Roof Panels Seal: Silicone caulk between panels and with another bead of caulk on panel seams after joining.
3. Roof Slope: Minimum 1 percent.
4. Roof Overlap: minimum of 1-inch over side panels around then entire unit.
5. Doors and Louvers: Provide a formed rain shield extending a minimum of 1-inch from the side walls to direct water away from doors and louvers.
6. [Weather-hoods: provide weather hoods and bird screens over all exposed inlets and outlets. Hoods may be shipped loose and separate for field installation.]
7. [Roof Finish: Exterior finish to have passed ASTM B 117-90 Salt Spray Resistance Test, minimum 1500 hours; ASTM D 2794-90 Impact Test, 160 pounds; ASTM D 2247-87 Humidity Resistance Test, minimum 1500 hour test with maximum blister 1/16-inch.]

E. Interior liners: Minimum 20 gauge steel with manufacturer’s standard finish, perforated throughout the unit for the walls and roof, except the cooling coil section and the evaporative cooling section and the plenum section immediately downstream shall have solid interior liner.

F. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced double-wall and insulated panels of same materials, thicknesses and finish as the unit casing.
2. Inspection and Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation.
   b. Arrangement: Shall allow panels to be opened against air-pressure differential.
   c. Gasket: Replaceable, neoprene, bulb-type applied around entire perimeters of panel frames.
   d. Size: Sufficient to allow inspection and maintenance of air-handling unit's internal components.
3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Replaceable, neoprene, bulb-type applied around entire perimeters of panel frames.
   c. Windows in Doors: Double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior neoprene seals. Minimum window size : 12-inch by 12-inch. Doors with access to moving parts must meet current UL mechanical protection guidelines.
   d. Door Size: Minimum 18 inches wide by full height of unit casing up to a maximum height of 72 inches. In the fan section, the door width must be sufficient for removal and replacement of a fan/motor assembly.
4. Locations and Applications:
   a. Fan Section: Doors with windows.
   b. Access Section: Doors with windows.
   c. Coil Section: Doors with windows.
   d. Damper Section: Doors with windows.
   e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
   f. Mixing Section: Doors with windows.
   g. Humidifier Section: Doors with windows.
G. Lights and Control Wiring

1. Internal Wiring Space: Fabricate air handler to allow minimum 1.5-inch clearance above the entire width of the each interior header-wall (coils, filters, fan septum-wall, etc.). This space is reserved for internal wiring (120-volt or 24-volt) as required by the Controls Contractor.

2. Internal Wiring Conduit: All factory wiring to lights, switches and convenience outlets shall be in conduit and internal to the air handler.

3. Service Lights: Vapor proof, LED A21 Lamp, 14-watt, light fixtures in each accessible section complete with a protective metal cage and sealed enclosure. Wire all lights to a common external junction box with a single illuminate switch, 120-volt GFCI outlet and weatherproof cover.

H. Condensate Drain Pans:

1. Material: Double-wall; 16-gauge, 304-stainless steel sheet, solid welds of all joints, seams and corners with space between walls filled with foam insulation.

2. Slope: Minimum one percent slope (1/8” per foot) in at least two planes

3. Location: Under cooling coils (including coil piping connections, coil headers, and return bends) and outside air inlets.

   a. Length: Extend drain pan H/2 from leaving face in the direction of the air flow, where “H” is the vertical height of the cooling coil, to comply with ASHRAE 62.1 Section 5.
   b. Depth: Minimum of 2-inch deep.
   c. Drain pan shall be fully recessed into the air handler floor.

4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan. Extend through channel/tube base on same side as coil connections unless noted otherwise on Plans.


5. Drain pan shall conform to all applicable requirements in ASHRAE 62.1.

6. Coils shall be easily removable without cutting or removing any portion of the drain pan.

7. Stacked Coils: Provide an intermediate drain pan to collect condensate from upper coils with drain pipe extending to lower pan.

8. Drain Pan Test: Perform drain pan test in compliance with ASHRAE 62.1 paragraph 7.3 (which permits factory or field testing). Provide manufacturer’s written certification of Drain Pan testing.

2.3 MULTIPLE FAN ARRAY UNITS

A. The Multiple Fan Array shall consist of multiple direct-driven Arrangement 4, 12-airfoil blades, non-overloading plenum fans designed and constructed specifically for Multiple Fan Array applications.

B. Fans: Selected to deliver design air flow at the specified operating Total Static Pressure at the specified motor speed as scheduled in the Plans. The Multiple Fan Array shall be selected to operate at a system Total Static Pressure that does not exceed 90 percent of the specified fan’s peak static pressure producing capability at the specified fan speed. Fans shall be AMCA 99-208 Class 2 construction.
C. Motors: Inverter-duty, Premium-efficiency T-frame motors selected at the voltage, frequency, and rpm as scheduled on the Plans and complying with requirements in Section 230515 Common Motor Requirements for HVAC Equipment.

D. Dynamic Balance: Comply with AMCA Standard 204-05 (R2012), Fan Application Category BV-4; Balance Quality Grade 2.5. The maximum allowable vibration shall be 0.08 inch per second peak velocity, filter-in as measured at the design fan speed.

1. Vibration Measurements: Taken on each fan bearing in the horizontal, vertical and axial directions. During balancing, the fan shall be imposed with an operating resistance equal to the design external static pressure.

2. Certificate of Compliance: Provide a Certificate of Compliance signed by the manufacturer and incorporated into the Operation and Maintenance Manuals.

E. Motor Shaft Grounding: Factory installed AEGIS Shaft Grounding Ring (SGR) microfiber type. Motor shaft isolation bearings, ceramic bearings and other SGR systems require Prior Approval from the Engineer. All fan motors shall be Lifetime Warranted against bearing failure from EDM pitting.

F. Motor Bearings: Pre-lubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated L-10 life of 200,000 hours according to ABMA 9.

G. Fan/motor assembly Access: Removable through the fan section access door without disassembling the Fan/motor Assembly.

H. Multiple fan installations must have a minimum of two (2) fans. The individual motor size shall not exceed 10.0 horsepower.

I. Blank-off Panel: Provide to temporarily isolate a fan that is not functional. Label the Blank-Off Panel and mount in an accessible location in the Fan Section. Fans with zero pressure drop isolation dampers do not require a Blank-off Panel.

J. Electrical Control Panel:

1. Each Fan/motor Assembly shall be individually wired to an Electrical Control Panel that provides overload protection, short circuit protection and a manual disconnect for each individual fan/motor assembly. Wire all circuits to a common main panel terminal block for a single point connection of power to the Air Handling Unit.

2. Code Compliance: Electrical designs, wiring and hardware in accordance with the current NEC, UL 508C and local codes. Electrical Control Panel shall be rated NEMA 1 Indoor.

3. Label and Listing: Control Panel shall be listed and labeled by UL, CSA or ETL. Air Handling Units not listed and labeled at the factory shall be inspected and labeled by a certified UL/CSA/ETL representative in the field at the manufacturer’s expense.

4. Location: Mounted on the exterior of the air handler.

5. Auxiliary Contacts: Provide contacts for alarm connections to the Building Management System.

6. Label and number code all wiring and electrical devices in accordance with the unit electrical diagram.

7. Control and Lighting Power: Provide control and lighting transformers wired to the common main panel terminal block for a single-point electrical connection for the air handling unit.

2.5 VARIABLE FREQUENCY DRIVES
A. Variable Frequency Drives (VFD's) shall be provided by Division 26.

2.7 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Hot Water, Chilled Water and Glycol Coils

1. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.
3. Working-Pressure/Temperature Ratings: Minimum 250 psig, 325 deg F.
4. Source Quality Control: Factory tested to 400 psig.
5. Tubes: ASTM B 743 copper, minimum 0.625 inch diameter, minimum 0.035 inch thick. Expanded into fin collars to provide permanent mechanical bond
6. Return Bends: Brazed replaceable copper, minimum 0.049 inch thick,
7. Fins: Aluminum, minimum 0.008 inch thick.
8. Headers: Seamless copper tube with brazed joints, prime coated, with cleaning plugs and drain and air vent tappings. Provide braze or copper male thread connections. Connections shall be on the same end of the coil. Extend vent and drain fitting to exterior of casing. All coils shall be fully drainable with no trapped tube.
9. Frames: Galvanized-steel channel frame, minimum 0.064 inch thick for flanged mounting. Provide intermediate coil casing reinforcement so maximum unsupported coil length is 60-inches. Provide integral stacking flanges on the coil for mounting stacked coils.
10. Connections: Supply and return connections shall be raised/lowered to facilitate piping connections near roof, floor and stacked coils. Coils shall be counter-flow design with connections right/left hand as shown on Plans. Use of internal flow restrictive devices, such as turbulator, springs, ribbons, is not acceptable. Extend coil supply and return piping connections through the cabinet wall and sealed with caulking and escutcheons inside and outside of the casing.

2.8 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. UL listed and labeled: UL 900 in accordance with NFPA 90A.
2. Provide minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Filter Section: Fabricated as an integral part of the air handling unit. Filter shall be upstream face loading as indicated on Plans. Face or rear loading shall be in gasketed universal holding frames. The filter rack assemblies shall blanked off to the sides, roof and floor and sealed to minimize filter bypass.
4. Provide filter holding frames arranged for flat or angular orientation, as indicated on Plans, with access doors, as indicated on Plans. Filters shall be lifted out from the access plenum.
5. See Filter Schedule on Plans for filter configuration and maximum filter face velocity.

B. Pleated Panel Filters:
1. **Description:** Factory-fabricated, self-supported, extended-surface, pleated, panel-type disposable air filters with holding frames.

2. **Media:** Interlaced glass or synthetic fibers coated with nonflammable adhesive.
   
a. **Adhesive:** As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

b. **Media** shall be coated with an antimicrobial agent.

c. **Separators** shall be bonded to the media to maintain pleat configuration.

d. **Welded-wire grid** shall be on downstream side to maintain pleat.

e. **Media** shall be bonded to frame to prevent air bypass.

3. **Filter-Media Frame:** Cardboard frame with perforated metal retainer sealed or boned to the media.

4. **Mounting Frames:** Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.

5. **Capacities and Characteristics:**
   
a. **Thickness or Depth:** 2-inches.

b. **MERV Rating:** 8 when tested according to ASHRAE 52.2.

C. **Filter Gages:**
   
1. **Dwyer 2000 Magnehelic gage;** in metal case; white face with black figures; front recalibration adjustment.

2. **Accuracy:** 2 percent of full-scale.

3. **Range:** 0- to 2.0-inch w.g.

4. **Accessories:** Static-pressure tips with integral compression fittings, 1/4-inch plastic tubing, and 3-way vent valves.

2.9 **DAMPERS**

A. **General Requirements for Dampers:** Low leak airfoil dampers bearing the AMCA Seal.

B. **Air performance and air leakage:** Based on tests and procedures performed in accordance with AMCA Publication 511. Comply with the requirements of the AMCA Certified Rating Program. Damper shall be AMCA Leakage Class 1A, 3.0 cubic feet per minute leakage at 1.0 inch w.g. pressure difference; AMCA Leakage Class 1, 8.0 cubic feet per minute leakage at 4.0 inch w.g. pressure difference through a 48-inch by 48-inch damper. Maximum blade length shall be 48-inches.

2.10 **DIRECT EVAPORATIVE COOLERS**

A. **General Requirements:**
   
1. **Cooler shall be self-cleaning design.**

2. **Cooler shall meet or exceed capacity and other features as scheduled on the Plans.**

3. **Provide a 120-volt GFCI outlet with weatherproof cover located to avoid nuisance trips from splashing water**

B. **Evaporative Media**
   
1. **Glass fibers impregnated with insoluble rigidifying saturants in a cross-fluted design.**

2. **Cooler shall meet or exceed capacity and other features as scheduled on the Plans.**
C. **Evaporative Cooler Housing**  
   1. Constructed of 16 gauge 304 Stainless Steel.

D. **Sump Pan**  
   1. Constructed of 10 gauge stainless steel. All joints, corners, and seams shall be welded continuously to be water-tight.
   2. Slope sump-bottom a minimum \( \frac{1}{4} \)-inch per foot.
   3. Drain connection shall be located so that pan drains completely.

E. **Piping**  
   1. All piping shall be extended to exterior of the cooler.
   2. All piping within the air stream shall be copper.
   3. Dual distribution header shall be provided for media depths that exceed 12 inches.
   4. Make-up line and level controls shall consist of a brass float valve, copper float, steel drain and overflow connections, water makeup, and fast fill connection.
   5. Provide a factory flow indicator at the pump discharge line for easy observation of proper water flow.
   6. The copper bleed line shall be furnished with an adjustable ball valve.

F. **Pump**  
   1. The pump shall be located outside of the air handler.
   2. Coolers shall be furnished with a submersible pump.

### 2.13 SOURCE QUALITY CONTROL

A. **Fan Sound-Power Level Ratings:** Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. **Fan Performance Rating:** Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. **Water Coils:** Factory tested to 400 psig and to 200 psig underwater according to ARI 410 and ASHRAE 33.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Units that are required to ship in multiple sections shall be assembled per manufacturer’s written instructions under the direction of a factory authorized representative.

B. Equipment Mounting:
   1. Install air-handling units on cast-in-place concrete equipment bases. Concrete equipment bases shall comply with overall size, thickness, and edge distance for anchor bolts required in Section 230548 “Vibration and Seismic Controls” Submittal.
   2. Equipment Bases: Comply with requirements specified in Section 033053 "Miscellaneous Cast-in-Place Concrete".
   3. Vibration Isolation and Seismic Control: Comply with requirements specified in Section 230548 “Vibration and Seismic Controls for HVAC.”

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters are in place. At Substantial Completion, replace temporary filters used during construction and testing, with new clean filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

D. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

E. Comply with requirements in Section 233300 “Air Duct Accessories.”

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative, prior to unit startup to inspect, and adjust components, assemblies, and equipment installations including connections.
   1. Complete manufacturer’s field assembly, installation and setup checklist.
   2. Prepare a written report of findings and recommended corrective actions signed by the factory-authorized service representative. Submit report to Architect along with copies of completed installation and setup checklist.
B. Tests and Inspections:

1. **Leak Test**: After installation, fill water coils with water, and test coils and connections for leaks.
2. **Fan 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. Air-handling Unit or components will be considered defective if Unit or components do not pass tests and inspections.

D. Prepare a written report of findings and corrective actions. Submit written report to Architect.

### 3.5 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. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Verify that proper thermal-overload protection is installed for electric coils.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

### 3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
3.7 CLEANING

A. After completing system installation, inspect interior and exterior finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches and abrasions to restore unit to new condition.

B. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings.

C. Install new, clean filters prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing and preventive maintenance.

1. Review data in the Operation and Maintenance Manual. Refer to Division 1 Section "Contract Closeout".
2. Schedule training with Owner through Architect with at least 7 days advance notice.

END OF SECTION 23 7313
SECTION 237423.16 - PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes indirect-fired makeup-air units.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, indirect-fired makeup-air unit.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type and configuration of outdoor, indirect-fired heating and ventilating unit.

1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
2. Include plans, elevations, sections, and mounting details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
5. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
7. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Startup service reports.

B. Sample Warranty: For manufacturer's special warranty.
C. Certified fan performance curves with system operating conditions indicated.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For indirect-fired makeup-air units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fan Belts: One set for each unit.

1.8 QUALITY ASSURANCE
A. Comply with NFPA 70.
B. Performance: Capacities and air deliveries to be certified by manufacturer as meeting national standards substantiated by valid test information. Airflow capacities to be AMCA rated.

1.9 WARRANTY
A. Special Warranty: Manufacturer agrees to repair or replace components of indirect-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AAON Inc.
   4. Hastings HVAC; Division of Eric, Inc.
   7. Sterling HVAC Products; a Mestek company.
   8. Trane Inc.
2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, and indirect-fired gas burner to be installed exterior to the building.

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.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:
   1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
   2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
   3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
   4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

A. Configuration:
   1. Horizontal unit with discharge orientation:
      a. Bottom
   2. Support installation: Roof-mounting.

B. Cabinet:
   1. Panel material;
      a. Aluminized- or galvanized-steel.
   2. Panels formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs.
   3. Duct flanges at inlet and outlet.
   4. Pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

A. Outer Casing:
   1. Material:
      a. 0.0598-inch thick steel.
   2. Finish:
      a. Heat-resistant, baked-enamel
   3. Surface prep:
      a. Over-corrosion-resistant-treated surface in color to match fan section.

B. Inner Casing:
   1. Burner Section Inner Casing: 0.0299-inch thick steel.
   2. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on;
      a. Complete unit
      b. Thickness: 1 inch.
c. Insulation Adhesive: Comply with ASTM C 916, Type I.
d. Density: 1.5 lb/cu. ft..
e. Mechanical Fasteners:
   1) Galvanized steel suitable for:
      a) Adhesive attachment to casing.
      b) Mechanical attachment to casing.
      c) Welding attachment to casing.
   2) Application of fastener:
      a) Will not damage liner when applied as recommended by manufacturer.
      b) Will not cause air leakage.

C. Casing Insulation and Adhesive:
   1. Materials: ASTM C 1071, Blanket, Type I.
   2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
      b. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
      c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.

   3. Location and Application: Encased between outside and inside casing.

D. Condensate Drain Pans:
   1. Fabricated with one percent slope in at least two planes to collect condensate from condensate-producing heat exchangers and from humidifiers, and to direct water toward drain connection.
      a. Length: Extend drain pan downstream from leaving face.
      b. Depth: A minimum of 2 inches deep.
   2. Formed sections.

2.4 ACCESSORIES

A. Service Platform:
   1. Material:
      a. Galvanized Steel.
   2. Features:
      a. 42 inches wide.
      b. Running entire length of unit.
      c. Located on service access side.
      d. Angle side rails.
      e. 4-inch kick plates.
      f. Expanded metal floor.
3. Ladder;
   a. Fixed ladder,
   b. Extending from the top of the side rail to the floor.

B. Duplex, **115-V**, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. **Outlet shall be energized even if the unit main disconnect is open.**

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

### 2.5 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

### 2.6 AIR WASHER COOLING SECTION

A. Attributes:
   1. 12" Munters CELdek (or equal) evaporative media.
   2. Submersible water pump.
   3. Schedule 40 P.V.C. water distribution system:
      a. Splash tube spray over media.
      b. Fill valve; Cast brass float type.
   4. Cabinet shall be constructed of:
      a. 18 gage aluminized steel painted exterior.
   5. Reservoir shall be:
      a. 20 gage stainless steel.

B. All other items shall comply with Section 237613 "Direct Evaporative Coolers".

### 2.7 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Curb Height: 14 inches .

C. Curb Height: 18 inches .

### 2.8 SUPPLY-AIR FAN

A. Fan Type:
   1. Centrifugal, rated according to AMCA 210; statically and dynamically balanced.
   2. Fan wheel material; Galvanized steel,
3. Fan wheel mounting; On solid-steel shaft.
4. Bearings, heavy-duty;
   a. Self-aligning, permanently lubricated ball bearings.
5. Bearing rating:
   a. \( L10 \) of 150,000 hours.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.9 AIR FILTERS

A. Comply with [NFPA 90A] [NFPA 90B].

B. Cleanable Filters: Cleanable metal mesh.
   1. Thickness: 1 inch
   2. Maximum Face Velocity: 350 fpm

2.10 DAMPERS

A. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.11 INDIRECT-FIRED GAS BURNER


1. CSA Approval: Designed and certified by and bearing label of CSA.
   a. Gas Control Valve:
      1) Modulating.
   b. Fuel: Natural gas.
   c. Minimum Combustion Efficiency: 80 percent.
   d. Ignition: Electronically controlled electric spark with flame sensor.
   a. High-Altitude capability, for Project elevation above sea level:
      1) Provided integral to particular Model

B. Venting: Gravity vented.


D. Heat-Exchanger Drain Pan: Stainless steel.

E. Safety Controls:
   2. Control Transformer: 24-V ac.
   3. High Limit: Thermal switch or fuse to stop burner.

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4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body with;  
   a. Hydraulic-modulating temperature control valve.  
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.  
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.  
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.  

2.12 UNIT CONTROL PANEL  
A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.  
B. Control Panel: Surface-mounted remote panel, with engraved plastic cover and the following lights and switches:  
   1. Fan switch: On-off.  
   4. Heating operation indicating light.  
   5. Thermostat.  
   6. Damper position potentiometer.  
   7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.  
   8. Safety-lockout indicating light.  
   9. Enclosure: NEMA 250:  
      a. Type 1.  

2.13 CONTROLS  
A. Comply with requirements in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for control equipment and sequence of operation.  
B. Fan Control: Interlock fan to start with exhaust fan to which this heating and ventilating unit is associated for makeup air.  
C. Temperature Control: Operates gas valve to maintain supply-air temperature.  
   1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.  
   2. Burner Control: Two or four steps of control using one or two burner sections in series.  
D. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display status and alarms of heating and ventilating unit.  
   1. Hardwired Points:  
      a. Room temperature.  
      b. Discharge-air temperature.  
      c. Burner operating.
2.14 MOTORS
A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   1. Enclosure:
      a. Open, dripproof.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Equipment Mounting:
   1. Install heating and ventilating unit on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.
B. Unit Support:
   1. Install heating and ventilating unit level on structural; curbs.
   2. Coordinate wall penetrations and flashing with wall construction.
C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.
A. Roof Curb (provided by unit mfg):
   1. Install on roof structure or concrete base, level and secure, according to; NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."
   2. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories."
   3. Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
A. Unit Support (field fabricated):
1. Install unit level on structural curbs.
2. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

3.3 CONNECTIONS

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

1. Gas Piping:
   a. Comply with requirements in:
   b. **Section 231123 "Facility Natural-Gas Piping."
   c. Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service.
   d. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain:
   1. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
   2. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

C. Duct Connections:
   1. Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors.
   2. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

A. Perform tests and inspections **with the assistance of a factory-authorized service representative.**

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. **Engage a factory-authorized service representative to perform** startup service.
B. Complete installation and startup checks according to manufacturer’s written instructions and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Purge gas line.
6. Inspect and adjust vibration isolators.
7. Verify bearing lubrication.
8. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
9. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer’s written instructions.

1. Complete startup sheets and attach copy with Contractor’s startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. 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 supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
   a. High-limit heat.
   b. Alarms.
11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
13. Verify outdoor-air damper operation.

3.6 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months 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.
3.7 DEMONSTRATION

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

END OF SECTION 237423.16
SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Ductless fan coil units and accessories.
   2. Ducted fan coil units and accessories.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
B. Shop Drawings:
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.
C. Samples for Initial Selection: For units with factory-applied color finishes.
D. Samples for Verification: For each type of fan coil unit indicated.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which fan coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
d. Sprinklers.
e. Access panels.

6. Perimeter moldings.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following:

   a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish two spare filters for each filter installed.

2. Fan Belts: Furnish two spare fan belts for each unit installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

   1. Failures include, but are not limited to, the following:
a. Compressor failure.
b. Condenser coil leak.

2. **Warranty Period**: Four years from date of Substantial Completion.

3. **Warranty Period (Compressor Only)**: Five years from date of Substantial Completion.

**PART 2 - PRODUCTS**

**2.1 SYSTEM DESCRIPTION**

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

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

**2.2 DUCTLESS FAN COIL UNITS**

A. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   1. Airtherm; a Mestek Company.
   2. Carrier Corporation; a UTC company.
   3. ENVIRO-TEC; by Johnson Controls, Inc.
   4. First Company Products.
   5. Greenheck Fan Corporation.
   6. McQuay International; Daikin Industries.
   7. Nailor Industries Inc.
   8. Titus.
   9. Trane Inc.
   10. YORK; by Johnson Controls, Inc.

**Fan Coil Unit Configurations**: Row split.

1. **Number of Heating Coils**: One with two-pipe system.
2. **Number of Cooling Coils**: One with two-pipe system.

C. **Coil Section Insulation**: 1/2-inch thick, **coated glass fiber** complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.

D. **Coil Section Insulation**: Insulate coil section according to Division 23 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
E. **Main and Auxiliary Drain Pans:** Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

F. **Chassis:** Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.

G. **Cabinet:** Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
   1. **Vertical Unit Front Panels:** Removable, steel, with steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. **Horizontal Unit Bottom Panels:** Fastened to unit with cam fasteners and hinge and attached with safety chain; with cast-aluminum discharge grilles.

H. **Filters:** Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
   1. Washable Foam: 70 percent arrestance and MERV 3.

I. **Hydronic Coils:** Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, 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.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 "Common Motor Requirements for HVAC Equipment."
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Division 23 "Instrumentation and Control for HVAC" and Division 23 "Sequence of Operations for HVAC Controls."

K. **DDC Terminal Controller:**
   1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
   2. Unoccupied-Period-Override Operation: Two hours.
   3. Unit Supply-Air Fan Operation:
      a. Occupied Periods: Fan runs continuously.
      b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
   4. Hydronic Cooling-Coil Operation:
      a. Occupied Periods: Modulate control valve to provide cooling if room temperature exceeds thermostat set point.
      b. Unoccupied Periods: Close control valve.
   5. Heating-Coil Operation:
      a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
b. **Unoccupied Periods**: Start fan and open control valve if room temperature falls below setback temperature.

6. Controller shall have volatile-memory backup.

L. Building Automation System (BAS) Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide **BACnet** interface for central BAS workstation for the following functions:
   
   a. Adjust set points.
b. Fan coil unit start, stop, and operating status.
c. Data inquiry to including supply-and room-air temperature.
d. Occupied and unoccupied schedules.

M. Electrical Connection: Factory wire motors and controls for a single electrical connection.

### 2.3 DUCTED FAN COIL UNITS

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

1. Carrier Corporation; a UTC company.
2. ENVIRO-TEC; by Johnson Controls, Inc.
3. First Company Products.
5. McQuay International; Daikin Industries.
6. Nailor Industries Inc.
7. Titus.
8. Trane Inc.
9. YORK; by Johnson Controls, Inc.

A. **Fan Coil Unit Configurations**: Row split.

1. **Number of Heating Coils**: One with two-pipe system.
2. **Number of Cooling Coils**: One with two-pipe system.

A. **Coil Section Insulation**: 1/2-inch thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.

B. **Coil Section Insulation**: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.

A. **Main and Auxiliary Drain Pans**: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1. **Drain pans shall be removable.**
B. **Chassis**: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.

C. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
   1. **Supply-Air Plenum**: Sheet metal plenum finished and insulated to match the chassis.
   2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
   3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with return-air, formed-steel dampers.
   4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

D. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
   1. Washable Foam: **70 percent** arrestance and MERV **3**.

E. **Hydronic Coils**: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch**, 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.

F. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

G. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

H. Control devices and operational sequence are specified in Division 23 "Vibration and Seismic Controls for HVAC Piping and Equipment."

I. **DDC Terminal Controller**:
   1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
   2. Unoccupied-Period-Override Operation: **Two hours**.
   3. Unit Supply-Air Fan Operation:
      a. Occupied Periods: Fan runs continuously.
      b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
   4. Hydronic-Cooling-Coil Operation:
      a. **Occupied Periods**: Modulate control valve to provide cooling if room temperature exceeds thermostat set point.
      b. Unoccupied Periods: Close control valve.
   5. Heating-Coil Operation:
      a. **Occupied Periods**: Open control valve to provide heating if room temperature falls below thermostat set point.
      b. **Unoccupied Periods**: Start fan and open control valve if room temperature falls below setback temperature.
6. Controller shall have volatile-memory backup.

J. Building Automation System (BAS) Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide **BACnet** interface for central BAS workstation for the following functions:
   a. Adjust set points.
   b. Fan coil unit start, stop, and operating status.
   c. Occupied and unoccupied schedules.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

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

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices:
   1. **48 inches** above finished floor.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.
   a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Division 23 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will 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 equipment installations, including connections.

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. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 238219
SECTION 238236 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes **hydronic** finned-tube radiation heaters.

1.3 DESCRIPTION OF WORK
A. Extent of terminal unit work is indicated by drawings and schedules, and by requirements of this section.
B. Refer to other Division-23 sections for piping; ductwork; and testing, adjusting and balancing of finned-tube radiation units.
C. Refer to Division-26 sections for the following work.
   1. Power supply wiring from power source to power connection on finned-tube radiation unit. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
D. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:
   1. Control wiring between field-installed controls, indicating devices, and finned-tube radiation unit control panels.
      a. Control wiring specified as work of Division-23 for Automatic Temperature Controls is work of that section.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings:
   1. Include plans, elevations, sections, and details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include details and dimensions of custom-fabricated enclosures.
   4. Indicate location and size of each field connection.
   5. Indicate location and arrangement of piping valves and specialties.
   6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
   2. Method of attaching finned-tube radiation heaters to building structure.
   3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATION HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dunham-Bush, Inc.
   2. Edwards Engineering Corp.
   3. Modine.
   4. Slant/Fin Corp.
   5. Standard Fin-Pipe Radiator Corp.
   6. Sterling HVAC Products; Mestek, Inc.
   7. Ted Reed Thermal, Inc.
   8. Trane.
   10. Zehnder Rittling

B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

A. Heating Elements: Copper tubing mechanically expanded into flanged collars to eliminate noise and insure durability and performance at scheduled ratings. Elements to consist of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled. See Drawing Schedules for the following capacities and characteristics.

B. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
Logan City School District - Ellis Elementary School

C. Front Panel: Minimum 17GA-0.0538-inch thick steel.

D. Rust-Resistant Front Panel: Minimum 16GA-0.064-inch thick, ASTM A 653, G60 galvanized steel.

E. Wall-Mounted Back Panel: Minimum 0.0329-inch thick steel, full height, with full-length channel support for front panel without exposed fasteners.

F. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

G. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

H. Finish: Baked enamel finish in manufacturer's standard color as selected by Architect.

I. Damper: Knob-operated internal damper at enclosure outlet.

J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

K. Enclosure Style: Flat top.
   1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
      c. Painted to match enclosure.
   2. Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      a. Top Outlet.
      b. Mill-finish aluminum.
      c. Anodized finish, color as selected by Architect from manufacturer's standard colors.
      d. Painted to match enclosure.

L. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of finned-tube radiation heaters.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 FINNED-TUBE RADIATION HEATER INSTALLATION

A. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.

B. Install units level and plumb.

C. Install enclosure continuously around corners, using outside and inside corner fittings.

D. Join sections with splice plates and filler pieces to provide continuous enclosure.

E. Install access doors for access to valves.

F. Locate finned tube radiation on outside walls as indicated. Install enclosure continuously from wall to wall.

G. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

H. Install valves within reach of access door provided in enclosure.

I. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

J. Install piping within pedestals for freestanding units.

K. Center elements under windows. Where multiple windows occur over units, divide elements into equal segments centered under each window.

L. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 23 "Hydronic Piping" and Division 23 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water finned-tube radiation heaters and components to piping according to Division-23 "Hydronic Piping" and Division-23 Hydronic Piping Specialties."

   1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Division-23 "Instrumentation and Control for HVAC."

D. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

E. Connect wiring according to Division-26 "Low-Voltage Electrical Power Conductors and Cables."

F. Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electric Installer.
G. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.4 FIELD QUALITY CONTROL

A. Perform the following field 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.
4. Appearance Test: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
   a. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238236
SECTION 238239.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.3 DEFINITIONS
A. BAS: Building automation system.
B. CWP: Cold working pressure.
C. PTFE: Polytetrafluoroethylene plastic.
D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings:
   1. Include plans, elevations, sections, and details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include location and size of each field connection.
   4. Include details of anchorages and attachments to structure and to supported equipment.
   5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
   6. Indicate location and arrangement of piping valves and specialties.

1.5 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Airtherm.
   2. Dunham-Bush.
   3. McQuay International; Daikin Industries.
   5. Rittling
   6. Ted Reed Thermal, Inc.
   7. Trane.
   8. Young Radiator Co.

2.2 DESCRIPTION
A. Factory-assembled and -tested unit complying with AHRI 440.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2.3 COIL SECTION INSULATION

A. **Insulation Materials**: ASTM C 1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.

   1. **Thickness**:
      a. 1/2 inch.
   2. **Thermal Conductivity (k-Value)**: \(0.26\) Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. **Fire-Hazard Classification**: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   4. **Adhesive**: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

2.4 CABINETS

A. **Material**: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect

   1. Vertical Unit, Exposed Front Panels: Removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Control Access Door: Key operated.
   3. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet:
      a. 6 inches high with leveling bolts.
   4. Extended Piping Compartment: 8-inch-wide piping end pocket.
   5. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.
   6. **Outdoor-Air Wall Box**: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen; aluminum louver with baked-enamel finish in color selected by Architect from manufacturer's standard colors.

2.5 FILTERS

A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

   1. Washable Foam: 70 percent arrestance and MERV 3.

2.6 COILS

A. **Hot-Water Coil**: 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.

2.7 CONTROLS

A. **Fan and Motor Board**: Removable.

   1. **Fan**: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
B. **Factory, Hot-Water Piping Package:** ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Provide equipment for one of the following operated valve arrangements:
   a. **Calibrated-Orifice Balancing Valves:** Bronze body, ball type, **125-psig** working pressure, **250 deg F** maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

2. Control valve:
   a. **Two-way, modulating** control valve.

3. **Hose Kits:** Minimum **400-psig** working pressure, and operating temperatures from **33 to 211 deg F**. Tag hose kits to equipment designations.
   a. **Length:** 24 inches.
   b. **Minimum Diameter:** Equal to cabinet unit-heater connection size.

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

5. **Y-Pattern, Hot-Water Strainers:** Cast-iron body (ASTM A 126, Class B); **125-psig** minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.

6. **Wrought-Copper Unions:** ASME B16.22.

C. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

D. **DDC Terminal Controller:**

E. **BAS Interface Requirements:**

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. **Interface** shall be **BAC-net** compatible for central BAS workstation and include the following functions:
   a. Adjust set points.
   b. Cabinet unit-heater start, stop, and operating status.
   c. **Data inquiry**, including supply-air and room-air temperature.
   d. Occupied and unoccupied schedules.

F. **Electrical Connection:** Factory-wired motors and controls for a single field connection.

**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 23 "Hydronic Piping," Division 23 Hydronic Piping Specialties," Division 23 "Steam and Condensate Heating Piping," and Division 23 Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Division 23 "Hydronic Piping" and Division 23 Hydronic Piping Specialties."

G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of cabinet unit heater. Steam specialties are specified in Division 23 Steam and Condensate Piping Specialties."

H. Ground equipment according to Division 23 "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 23 "Low-Voltage Electrical Power Conductors and Cables."
3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

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SECTION 26 0001
ELECTRICAL GENERAL PROVISIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Architectural, Structural, Mechanical and other applicable documents also apply to work of this section.

1.2 DESCRIPTION OF WORK:

A. The contract documents indicate the extent of electrical work. Provide all labor, materials, equipment, supervision and service necessary for a complete electrical system as described in divisions 26, 27, and 28.

1.3 RELATED SECTIONS:

A. Other Divisions relating to electrical work apply to the work of this section. See other applicable Divisions including, but not necessarily limited to:

1. Division 1 – General and Supplementary Conditions
2. Division 2 – Existing Conditions
3. Division 3 – Concrete
4. Division 5 – Metals
5. Division 6 – Wood, Plastics, and Composites
6. Division 7 – Thermal and Moisture Protection
7. Division 8 – Openings
8. Division 9 – Finishes
9. Division 21 – Fire Suppression
10. Division 22 – Plumbing
11. Division 23 – Heating Ventilating and Air Conditioning
12. Division 27 – Communications
13. Division 28 – Electronic Safety and Security

1.4 INTERPRETATIONS OF DRAWINGS AND SPECIFICATIONS:

A. Prior to bidding the job, submit requests for clarification in writing to the Architect/Engineer prior to issuance of the final addendum.

B. After signing the contract, provide all materials, labor, and equipment to meet the intent, purpose, and function of the contract documents.

C. The following terms used in Division 26, 27, and 28 documents are defined as follows:

1. "Provide" - Means furnish, install, and connect, unless otherwise indicated.
2. "Furnish" - Means purchase new and deliver in operating order to project site.
3. "Install" - Means to physically install the items in-place.
4. "Connect" - Means make final electrical connections for a complete operating piece of equipment. This includes providing conduit, wire, terminations, etc. as applicable.
5. "Or Equivalent" - Means to provide equivalent equipment. Such equipment must be approved by the Engineer prior to bidding.

1.5 EXAMINATION OF SITE:

A. Visit the site and verify existing field conditions prior to submitting bid.
B. All costs arising from site conditions and/or preparation shall be included in the base bid. No additional charges will be allowed due to inadequate site inspection.

1.6 QUALITY ASSURANCE:

A. Perform work in accordance with all governing codes, rules, and regulations including the following minimum codes (latest editions or as otherwise accepted by the Authorities Having Jurisdiction):

1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Fire Code (IFC)
4. International Mechanical Code (IMC)
5. International Plumbing Code (IPC)
6. American Disability Act (ADA)
8. Local Codes and Ordinances

B. Comply with all standards where applicable for equipment and materials including the following minimum standards:

1. Underwriter's Laboratories (UL)
2. American Society for testing Materials (ASTM)
3. Certified Ballast Manufacturers (CBM)
4. Insulated Cable Engineers Association (ICEA)
5. National Electrical Manufacturer's Institute (NEMA)
6. American National Standards Institute (ANSI)
7. Electrical Testing Laboratories (ETL)
8. National Fire Protection Association (NFPA)
9. Institute of Electrical and Electronics Engineers (IEEE)
10. American Institute of Electrical Engineer's Electrical Power Systems and Grounding in Commercial Construction
11. Illuminating Engineers Society (IES)

C. Provide new electrical equipment conforming to all requirements as set forth in the above standards. Provide UL labeled equipment where such label is applicable.

D. Comply with all state and local codes and ordinances. When conflicts occur among codes, standards, drawings, and/or specifications, the most stringent requirements shall govern.

E. Obtain all permits, inspections, etc. required by authority having jurisdiction. Include all fees in bid. Provide a certificate of approval to the owner's representative from the inspection authority at completion of the work.

F. Provide only first-class workmanship from competent workers, conforming to the best electrical construction practices.
G. The contractor shall have a current state contracting license applicable to type of work to be performed under this contract.

1.7 SUBMITTALS:

A. The contractor shall submit complete shop drawings and other required submittals. Incomplete submittals will be returned to the contractor unreviewed. No time extensions or cost increases will be allowed for delays caused by the return of incomplete submittals.

B. Shop Drawings: After the contract is awarded, but prior to manufacture or installation of any equipment, submit eight (8) complete sets of shop drawings. Partially complete sets of shop drawings are not acceptable. Submit all shop drawings in one complete submittal package. Prior to submitting shop drawings, review and certify that they are in compliance with the contract documents; Sign all approved shop drawings. Allow a minimum of two weeks for architect/engineer to review shop drawings. Refer to architectural general provision section for additional requirements.

C. Provide equipment catalog "cut sheets", brochures and/or drawings which clearly describe the proposed equipment. Include plans, elevations, sections, isometrics, and detailed engineering and dimensional information as applicable including equipment room layouts. Electrical room layouts are required to show all electrical equipment locations for all projects that include electrical rooms. Do not submit catalog sheets which describe several different items in addition to those items to be used, unless all relevant information is clearly identified. Bind each information set in three ring binder or binders of sufficient size or sizes to enclose all information. Organize all information by section. Provide separate tabbed covers for each section of Divisions 26, 27, and 28, indicating section number for each section requiring submittals.

D. Include on front cover of binder or binders the name and location of the project, architect, electrical engineer, general contractor, electrical contractor, subcontractors, supplier/vendor, order number, volume, date, and any other applicable information. Certify that shop drawings are submitted in accordance with the contract documents with a written statement indicating compliance. Submittals will be reviewed and comments produced two times maximum. Additional reviews will be billed at current rates.

1.8 OPERATION AND MAINTENANCE MANUALS:

A. Submit four (4) complete sets of operating instruction and maintenance manuals for all equipment and materials provided under Divisions 26, 27, and 28.

B. Provide manufacturer's recommended operating and maintenance instructions, cleaning and servicing requirements, serial and model number of each piece of equipment, complete list of replacement parts, performance curves and data, wiring diagrams, warranties, and vendor's name, address, and phone numbers. Do not submit information which describes several different items in addition to those items to be used, unless all relevant information is clearly identified. Assemble all data in completely indexed volume or volumes. Engrave the job title, and name, address, and phone numbers of the contractor on the front cover and on the spine. Incomplete O&M manuals will be returned to the contractor for corrections / additions.

1.9 RECORD DRAWINGS:

A. Maintain on a daily basis a complete set of "Red-Lined Drawings", reflecting an accurate record of all work including addendums, revisions, and changes. Indicate precise dimensioned locations of all concealed work and equipment, including concealed or embedded conduit, junction boxes, etc. Record all "Red-Lined Drawing" information on a set of full sized prints of
the contract drawings.

B. Certify the "Red Lined Drawings" for correctness. Indicate on each drawing the name of the general and electrical contractors with signatures of each representative responsible for the work.

C. The electrical engineering design firm will create record (as-built) drawings from the certified red-lined drawings; however, the general and electrical contractors retain the responsibility for the accuracy of the record drawings.

1.10 WARRANTY:

A. Ensure that the electrical system installed under this contract is in proper working order and in compliance with drawings, specifications, and/or authorized changes and is free from electrical defects. Without additional charge, replace or repair, to satisfaction of the owner's representative, except from ordinary wear and tear, any part of the installation which may fail or be determined unacceptable within a period of one (1) year after final acceptance or as otherwise indicated in individual sections, but in no case less than one year. Warranty incandescent and fluorescent lamps only for a period of two months from the date of substantial completion.

B. Provide complete warranty information for each item including beginning of warranty period, duration of warranty, names, addresses, and telephone numbers and procedures for filling a claim and obtaining warranty services. Written warranties and guarantees are to be submitted separately as:

1. Originals bound in a binder clearly identified with the title, “WARRANTIES AND GUARANTEES,” the project name, the project number, and the Contractor’s business name.
2. Electronic documents in *.pdf format.

PART 2 – PRODUCTS

2.1 GENERAL:

A. All materials shall be new and shall bear the manufacturer's name, trade name, and the approved testing laboratory such as the UL label in every case where a standard has been established for that particular material. Used materials are acceptable only if specifically indicated on drawings.

2.2 SUBSTITUTION OF MATERIALS:

A. Provide only specified products or products approved by addendum. Substitutions will be considered if two copies of the proposal is received at the architect's/engineer's office eight (8) working days prior to the bid day. Include in the proposal the specified and proposed catalog numbers of the equipment under consideration and a catalog cut sheet(s) with pictorial and descriptive information. Certify that the equipment proposed is equal to that specified, that it has the same electrical and physical characteristics, compatible dimensions, and meets the functional intent of the contract documents.

B. It is the responsibility of the contractor to make all substituted equipment comply with the intent of the contract documents and bear all cost associated with conflicts arising form the use of substituted equipment.
C. Provide samples if so required by the architect or engineer before or after bid day.

2.3 SPARE PARTS:

A. Provide spare parts as specified in Divisions 26, 27, and 28 sections. Deliver all spare parts to owner's representative prior to substantial completion.

PART 3 – EXECUTION

3.1 GENERAL:

A. Workmanship: Provide only first class workmanship from competent workers. Defective materials or workmanship will not be allowed on the project. Provide competent supervision for the work to be accomplished. Keep same foreman on the job, unless a change is authorized by the engineer.

B. Coordination: Prior to construction, layout electrical work and coordinate work with other trades. Sequence, coordinate, and integrate installation of materials and equipment for efficient flow of the work. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components. Coordinate with all utilities including power, communication, and data installations.

C. Provide cutting, drilling, channeling, etc. only as necessary for proper completion of the work. Do not cut structural members unless authorization is issued in writing by the architect/engineer.

D. Repairs: Repair damage to building, grounds, or utilities as a result of work under this contract at no additional cost to the owner.

E. Dimensioning: Electrical drawings indicate locations for electrical equipment only in their approximate location, unless specifically dimensioned. Do not scale electrical drawings for dimensional information. Refer to architectural drawings and shop drawings where applicable for locations of all electrical equipment. Field verify all dimension on the job site.

F. Provide block-outs, sleeves, demolition work, etc., required for installation of work specified in this division.

G. Standards: Provide electrical installation in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

H. All workmen doing work of any nature on State of Utah projects must at all times carry their electrician's license with them and show it upon request. The acceptable ratio of apprentice to journeyman electricians on the job is 1:1.

3.2 REQUESTS FOR INFORMATION:

A. When it is clearly apparent that information is not adequately described in the construction documents or when a coordination problem exists, submit a request for information (RFI) through proper contractual channels. The electrical engineering design firm will provide a
response through its contractual channel. Although verbal direction may be given to expedite
changes, responses are not considered part of the contract documents until a change order has
been issued and signed by the Owner or his designated representative. The Contractor shall
bear all costs associated with proceeding on any change order that has not been approved by
the Owner or his designated representative.

3.3 SAFETY PRECAUTIONS:

A. Provide all necessary guards or construction barriers and take all necessary precautions to
insure the safety of life and property.

3.4 CLEAN:

A. Clean up all equipment, conduit, fittings, wire, packing cartons, plastic, and other debris that is a
direct result of the installation of the work of this division, both during the execution, and at the
conclusion, of the project. Keep the site clean and safe during the progress of the work. Clean
fixtures, interior and exterior of all equipment, and raceways prior to final acceptance. Vacuum
interior of all electrical panels and equipment. Correct any damaged equipment. Touch-up or
repaint if necessary.

3.5 TEMPORARY POWER:

A. Make arrangements with the proper institution authority for all temporary electricity.

B. Provide temporary power, complete with metering and wiring for lighting and power outlets for
construction tools and equipment. Report the initial meter reading to the owner/institution, or
otherwise as may be directed.

C. Service shall be provided with a main disconnect and all 20 ampere receptacles protected by 20
amp GFI, single-pole breakers. No attempt is made herein to specify construction power
requirements for equipment in detail. Provide all electrical equipment and wiring as required.

D. As soon as permanent power and metering is available, the temporary power supply shall be
disconnected and removed from the project site.

E. All temporary wiring shall meet the requirements of NEC Article 305 and the State Industrial
Commission.

3.6 POWER OUTAGES:

A. All power outages required for execution of this work shall occur during non-standard working
hours and at the convenience of the owner. Any electrical service interruption will be
coordinated at least 7 days in advance of the power shut-off. Include all costs for overtime work
in bid. Coordinate all outages and proceed only after receiving authorization from the owner’s
representative. Keep all outages to an absolute minimum.

3.7 STORAGE AND PROTECTION OF MATERIALS:

A. Provide storage space for storage of materials and apparatus and assume complete
responsibility for all losses due to any cause whatsoever. Lost or damaged materials will be
replaced at no additional cost to owner. Do not store materials and apparatus in any public
thoroughfare or in any area on the site where such storage would constitute a hazard to
persons in the vicinity. Protect completed work, work underway, and apparatus against loss or
damage.
3.8 EXCAVATING FOR ELECTRICAL WORK:

A. Verification: Prior to excavating, locate and protect existing utilities and other underground work in a manner which will ensure that no damage or service interruption will result from excavating and backfilling. Observe all State and Local codes prior to excavating. Do not disturb walls, footings, and other structural members in any way.

B. Protection: Provide barricades, warning signs, and illumination to protect persons from injury at excavations. Provide temporary coverings and heat as necessary to protect bottoms of excavations from freezing and frost action. Do not install electrical work on frozen excavation bases or subbases.

C. Coordination: Do not excavate for electrical work until the work is ready to proceed without delay.

D. Excavated Materials: Temporarily store excavated materials near excavation in manner which will not interfere with or damage excavation or other work. Dispose of and remove excavated materials which are either in excess of quantity needed for backfilling or do not comply with the requirements for backfill material.

E. Burial Depths: Burial depths must comply with NEC Section 300-5 (or State of Utah requirements, whichever is more stringent), unless noted otherwise on drawings.

F. Excavation Permits: Obtain all shut-down and excavation permits as may be required for proper completion of the work.

3.9 BACKFILL MATERIALS:

A. For buried conduits or cables (other than below slab-on-grade, or concrete-encased), provide 2" thickness of well-graded sand on all sides of conduits or cables.

B. For trench backfill to within 6" of final grade, provide soil material suitable for compacting to required densities.

C. For top 6" of excavation, provide top soil.

D. Backfill excavations in 8" high courses of backfill material, uniformly compacted to the following densities (percent of maximum density, ASTM D 1557), using power-driven hand-operated compaction equipment:

1. Lawn/Landscaped Areas: 85 percent for cohesive soils, 95 percent for cohesionless soils.
2. Paved Areas, other than roadways: 90 percent for cohesive soils, 95 percent for cohesionless soils.

E. Where subsidence is observable at electrical work excavations during project warranty period, remove surface, add backfill material, compact, and replace surface treatment. Restore surface to original condition.

3.10 ROOF PENETRATIONS:

A. Where raceways and/or cables penetrate roofing, provide 26 gauge galvanized iron roof jack, sized to fit tightly to raceway and/or cable for weather-tight seal, and with flange extending a minimum of 9" under roofing on all sides. Seal opening between raceway and roof jack with approved sealant. Coordinate all work with division 7.
3.11 FIRE PENETRATION SEALS:

A. Seal all raceway and/or cable penetrations through fire-rated floors, wall, and ceilings to prevent the spread of smoke, fire, toxic gas or water through the penetration either before, during or after fire. Provide penetration sealants and fittings of ratings to match the rating of the penetrated materials so that the original fire rating of the floor or wall is maintained as required by Article 300-21 of the NEC.

B. Sealant Systems: Provide sealants, wall wraps, partitions, caps, and other accessories complying with UL 1479 (ASTM E-814) from the following where applicable:

1. 3M Fire Barrier Sealing Penetration System
2. Chase Foam Fire Stop System
3. Thomas and Betts Flame Safe Fire Stop System
4. Nelson Fire Stop Products

C. Fittings: Where applicable, provide OZ Type CFSF/I and CAFSF/I fire seal fittings for conduit and cable penetrations through concrete and masonry wall, floor, slabs, and similar structures.

D. Install sealants and fittings in accordance with all manufacturer's written instructions.

3.12 LABELING:

A. Engraved black plastic laminated, with white-core labels, 1/16" thick, shall be permanently attached on both the interior and exterior the following electrical equipment:

1. Branch panels
2. Switchgear
3. Disconnect switches
4. Motor starter and controls junction boxes (power and auxiliary)
5. Push buttons
6. Thermal switches
7. Time switches
8. Motor control centers
9. Transformer
10. Similar equipment.
11. Lighting control panels
12. Lighting contactors and associated switches
13. Junction boxes larger than 4x4x1/2.

B. The labels shall have 1/4" high, engraved letters, such as EF-1, AC-1, Panel A, etc.

3.13 CONCRETE BASES:

A. Housekeeping Pads: Unless otherwise noted, provide 4" high reinforced concrete bases for all floor-mounted or floor-standing electrical equipment, including but not necessarily limited to the following:

1. Transformers
2. Switchgear
3. Motor control centers
4. Battery racks
5. Similar Equipment

B. Extend bases 6" beyond equipment or mounting rails on all sides or as shown on the drawings.
Notwithstanding this requirement, coordinate with equipment manufacturer, shop drawings, and height of base to ensure compliance with NEC 380-82.

C. Concrete bases: Refer to Section 26 0551 – Exterior Area Lighting.

D. Transformer Pads: Provide and locate properly sized concrete pads for power company furnished pad mounted transformers in accordance with power company clearance requirements.

3.14 TESTS:

A. Notify engineer prior to all testing specified herein at least three business days prior to testing. Engineer shall observe all tests to insure the proper operation of the electrical system.

3.15 PROJECT FINALIZATION AND START-UP:

A. Upon completion of the work, have each factory representative and/or subcontractor assist in start-up and testing of their respective systems.

B. Have each representative give personal instructions on operating and maintenance of their equipment to the owner's maintenance and/or operation personnel.

C. Have representatives certify each system with a written statement indicating that they have performed start-up and final check out of their respective systems.

3.16 FINAL REVIEW:

A. Have the project foreman accompany their reviewing parties and remove coverplates, panel covers, access panels, etc. as requested, to allow review of the entire electrical system.

END OF SECTION 26 0001
SECTION 26 0070
ELECTRICAL CONNECTIONS FOR EQUIPMENT

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
   A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
   B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to electrical connections.

1.2 DESCRIPTION OF WORK:
   A. Extent of electrical connections for equipment include all final electrical connections for all equipment having electrical requirements including, but not necessarily limited to the following:
      1. Equipment specified under all divisions of the contract. Refer to other divisions for specific electrical requirements.
      2. Owner-furnished equipment
      3. Kitchen Equipment

1.3 QUALITY ASSURANCE:
   A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.
   B. SHOP DRAWINGS: Not required.

PART 2 – PRODUCTS

2.1 GENERAL:
   A. Provide all materials for electrical connections including, but not necessarily limited to the following:
      1. Raceways
      2. Fittings
      3. Conductors
      4. Cords
      5. Cord caps
      6. Wiring devices
      7. Pressure connectors
      8. Lugs (CU-AL)
      9. Electrical insulating tape
      10. Heat-shrinkable tubing
      11. Cable ties
      12. Wire nuts
      13. Other items and accessories as required.
B. Crimp on or slip-on type splicing materials designed to be used without wire stripping are not acceptable.

C. Power Distribution Blocks: Provide Square D Type LB or Equivalent.

D. Refer to other Division 26, 27, and 28 Sections for specification of electrical materials as applicable.

PART 3 – EXECUTION

3.1 GENERAL:
A. Make electrical connections in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA Standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 CONNECTIONS:
A. Permanently Installed Fixed Equipment:
   1. Install conductors in flexible conduit from junction box to equipment control panel or connection point.
   2. Where such installations are subject to moisture, install in liquid-tight flexible conduit.

B. Movable equipment:
   1. Provide wiring devices, cord caps, and multi-conductor cables as required.

C. Other methods as required by the NEC and/or as required by special equipment or field conditions.

D. Power Distribution Blocks: Unless noted otherwise on drawings, provide power distribution blocks only for tapping of feeders and branch circuits. Locate in junction box or gutter in NEMA ratings to suit application.

3.3 MANUFACTURER'S INSTRUCTIONS:
A. Obtain manufacturer's instruction and wiring diagram regarding electrical connections of each piece of equipment and provide connections in accordance therewith.

3.4 VERIFICATION OF LOAD CHARACTERISTICS:
A. Verify electrical load characteristics of all equipment prior to rough-in. Review respective shop drawings of all other Divisions and Owner's equipment manuals. Report any variances from electrical characteristics noted in the contract documents to the Architect/Engineer prior to rough-in.

END OF SECTION 26 0070
SECTION 26 0072
ELECTRICAL SUPPORTS AND SEISMIC RESTRAINTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY:

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Seismic restraints for electrical equipment and systems.
3. Construction requirements for concrete bases.

1.3 DEFINITIONS:


B. Seismic Restraint: A structural support element such as a metal framing member, a cable, an anchor bolt or stud, a fastening device, or an assembly of these items used to transmit seismic forces from an item of equipment or system to building structure and to limit movement of item during a seismic event.

1.4 SUBMITTALS:

A. Product Data: Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of electrical support and seismic-restraint component used.

1. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
2. Annotate to indicate application of each product submitted and compliance with requirements.

B. Shop Drawings: Indicate materials and dimensions and identify hardware, including attachment and anchorage devices, signed and sealed by a qualified professional engineer. Include the following:

1. Fabricated Supports: Representations of field-fabricated supports not detailed on Drawings.
2. Seismic Restraints: Detail anchorage and bracing not defined by details or charts on Drawings. Include the following:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Detail fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions.
and values of forces transmitted to the structure during seismic events.

c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE:

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Testing of Seismic Anchorage Devices: Comply with testing requirements in Part 3.

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

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

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

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

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS:

A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed under this Project, with a minimum structural safety factor of five times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-3, factory-fabricated components for field assembly.

1. Available Manufacturers:
   a. Cooper B-Line; a division of Cooper Industries.
   b. ERICO International Corporation.
   c. Allied Support Systems; Power-Strut Unit.
   d. GS Metals Corp.
   e. Michigan Hanger Co., Inc.; O-Strut Div.
   f. National Pipe Hanger Corp.
   g. Thomas & Betts Corporation.
   h. Unistrut; Tyco International, Ltd.
Ellis Elementary School

ELECTRICAL SUPPORTS AND SEISMIC RESTRAINTS

1. Wesanco, Inc.

2. Finishes:
   a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-3.

3. Channel Dimensions: Selected for structural loading and applicable seismic forces.

C. Raceway and Cable Supports: As described in NECA 1.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

   1. Verify suitability of fasteners in subparagraph below for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.
   2. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Available Manufacturers:
         1) Hilti, Inc.
         2) ITW Construction Products.
         3) MKT Fastening, LLC.
         4) Simpson Strong-Tie Co. Inc.
   3. In the following subparagraph, use stainless steel anchors in corrosive environments.
   4. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
      a. Available Manufacturers:
         1) Cooper B-Line; a division of Cooper Industries.
         2) Empire Tool and Manufacturing Co., Inc
         3) Hilti, Inc.
         4) ITW Construction Products.
         5) MKT Fastening, LLC.
         6) Powers Fasteners.
   5. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
   7. Toggle Bolts: All-steel springhead type.

2.3 SEISMIC-RESTRAINT COMPONENTS:

A. Rated Strength, Features, and Application Requirements for Restraint Components: As defined in reports by an agency acceptable to authorities having jurisdiction.

   1. Structural Safety Factor: Strength in tension, shear, and pullout force of components
used shall be at least five times the maximum seismic forces to which they will be subjected.

B. Angle and Channel-Type Brace Assemblies: Steel angles or steel slotted-support-system components; with accessories for attachment to braced component at one end and to building structure at the other end.

C. Cable Restraints: ASTM A 603, zinc-coated, steel wire rope attached to steel or stainless-steel thimbles, brackets, swivels, and bolts designed for restraining cable service.

1. Available Manufacturers:
   a. Amber/Booth Company, Inc.
   b. Loos & Co., Inc.
   c. Mason Industries, Inc.
2. Seismic Mountings, Anchors, and Attachments: Devices as specified in Part 2 "Support, Anchorage, and Attachment Components" Article, selected to resist seismic forces.
3. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod, of design recognized by an agency acceptable to authorities having jurisdiction.
4. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to type and size of anchor bolts and studs used.
5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to type and size of attachment devices used.

2.4 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES:

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

PART 3 – EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for raceways as within 12 inches of coupling, fitting, and box, at each 90 degrees bend, minimum of two supports per ten-foot run. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps, or as otherwise required by an agency acceptable to authorities having jurisdiction.

3.2 SUPPORT AND SEISMIC-RESTRAINT INSTALLATION:
A. Comply with NECA 1 for installation requirements, except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, raceways may be supported by openings through structure members, as permitted in NFPA 70.

C. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component.

D. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

G. Do not drill or core cut holes for anchors or use powder-activated fasteners in post-tension slabs, joists, and beams.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS:

A. Comply with installation requirements in Division 5 Section "Metal Fabrications" for site-fabricated metal supports.

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

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

3.4 CONCRETE BASES:

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer’s written instructions and seismic criteria at Project.
B. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so expansion anchors will be a minimum of 10 bolt diameters from edge of the base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of the base.
2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
6. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Section "Cast-in-Place Concrete."

3.5 INSTALLATION OF SEISMIC-RESTRAINT COMPONENTS:

A. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Restraint Cables: Provide slack within maximums recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.6 FIELD QUALITY CONTROL:

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.


1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Record test results.

END OF SECTION 26 0072
SECTION 26 0110
CONDUIT RACEWAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to conduit raceways.

1.2 DESCRIPTION OF WORK:
A. Extent of raceways is indicated by drawings and schedules.
B. Types of raceways in this section include the followings:
   1. Rigid Metal Conduit
   2. PVC Externally Coated Rigid Steel Conduit
   3. Intermediate Metal Conduit
   4. Electrical Metallic Tubing
   5. Flexible Metal Conduit
   6. Liquid-tight Flexible Metal Conduit
   7. Rigid Non-metallic Conduit
   8. Electrical Non-metallic Tubing

1.3 QUALITY ASSURANCE:
B. Manufacturers: Firms regularly engaged in the manufacture of raceway of types and sizes required, whose products have been in satisfactory service for not less than three (3) years.
C. Shop Drawings: Not required.

PART 2 - PRODUCTS

1.4 CONDUITS:
B. PVC Externally Coated Rigid Metal Conduit: Provide hot-dipped galvanized, rigid metallic conduit externally coated with Polyvinyl Chloride (PVC) in accordance with ANSI C80.1 and NEMA Std. Pub. No. RN 1.

D. Electric Metallic Tubing (EMT): Provide electric metal tubing in accordance with Federal Specification WW-C-563 and ANSI C80.3.

E. Flexible Metal Conduit: Provide zinc-coated, flexible metal conduit in accordance with Federal Specification WW-C-566.

F. Liquid-Tight Flexible Metal Conduit: Provide liquid-tight, flexible metal conduit, constructed of single strip, flexible continuous, interlocked, and double-wrapped steel, galvanized inside and outside, coated with liquid-tight jacket of flexible Polyvinyl Chloride (PVC).

G. Rigid Non-Metallic Conduit: Provide rigid non-metallic conduit (PVC) in accordance with ANSI/NEMA TC 2, Type 1 for concrete encasement, Type 2 for direct burial.

1.5 FITTINGS:

A. Rigid Metal Conduit, Intermediate Metal Conduit, and PVC Externally Coated Rigid Metal Conduit: Provide fully-threaded, malleable steel fittings, rain-tight and concrete-tight as applicable. Provide double locknuts and metal bushings at all conduit terminations. Install OZ Type B bushings on conduits 1-1/4" and larger.

B. Electric Metallic Tubing: Provide insulated throat, non-indenter, set screw, malleable steel fittings. Screws must have a full set. Provide concrete-tight compression-type fittings in suspended slabs. All EMT fittings shall be fabricated from steel. Die-cast fittings or fittings made from pot metal shall not be allowed. Indenter type fittings are not acceptable. Install OZ Type B bushings on conduits 1" and larger.

C. Flexible Metal Conduit: Provide flexible metal conduit fittings in accordance with Federal Specification W-F-406, Type 1, Class 1, and Style A. Commercial "greenfield" not less than 1/2" diameter or as otherwise specified on drawings is acceptable.

D. Liquid-Tight Flexible Metal Conduit: Provide liquid-tight flexible metal conduit fittings in accordance with Federal Specification W-F-406, Type 1, Class 3, Style G.

E. Non-Metallic Conduit: Provide non-metallic conduit fittings (PVC) in accordance with ANSI/NEMA TC 3 to match conduit types and materials.

F. Expansion Fittings: OZ Type AX, or equivalent to suit application.

G. Sealing Bushings: Provide OZ Type FSK, WSK, or CSMI as required by application. Provide OZ Type CSB internal sealing bushings.

H. Cable Supports: Provide OZ cable supports for vertical risers, type as required by application.

1.6 SIZES:

A. Provide conduits in sizes as indicated in contract documents or as otherwise specified herein, but not less than 3/4". Minimum sizes for data conduits is 1".

PART 3 - EXECUTION
1.7 GENERAL:

A. Install raceway and accessories in accordance with manufacturer’s written instructions, applicable requirements of NEC, NEMA Standards, and NECA’s “Standards of Installation”, and in compliance with recognized industry practices to ensure that products fulfill requirements.

1.8 LOCATIONS:

A. Rigid Metal Conduit and Fittings: Use for conduit bends greater than 22 degrees where buried below grade or slab on grade. Install RMC where raceway passes vertically through slab-on-grade. Where raceways penetrate building, manholes, or vault walls and floors below grade, provide RMC for a minimum distance of 10’ on the exterior side of the floor or wall. Use RMC for exposed runs where conduit is subject to moisture, weather, or mechanical injury. Use in hazardous locations in accordance with all NEC requirements.

B. Intermediate Metal Conduit and Fittings: Use for exposed runs where conduit is subject to moisture, weather, or mechanical injury. Use in hazardous locations in accordance with all NEC requirements.

C. Electric Metal Tubing and Fittings: Use for above-grade feeders, branch circuits, and signal and control circuit, unless specifically noted otherwise on drawings. Install in suspended slabs subject to local code requirements and fire rating considerations.

D. Flexible Metal Conduit and Fittings: Use as whips for lighting fixtures, fixed equipment where not exposed to weather of moisture, other devices where required by NEC, and as requested by the Engineer. Maximum length not to exceed 6’, unless specifically approved by the Electrical Engineer.

E. Liquid-Tight Flexible Metal Conduit and Fittings: Use for connection to motor terminal boxes, fixed equipment where subject to moisture or weather, and other equipment subject to movement or vibration. Maximum length not to exceed 6’, unless specified otherwise.

F. Rigid Non-Metallic Conduit and Fittings: Use for below-grade service entrances, feeders, branch circuits, and signal and control circuit, unless specifically noted otherwise on drawings. Do not use above grade.

1.9 METHODS:

A. Maintain a minimum of 12” clearance between steam or hot water lines or other hot surfaces. Where such clearance is impractical, insulate conduit with approved materials.

B. Install conduits parallel with or at right angles to lines of the structure. Route conduits symmetrically where possible.

C. Field bends and offsets shall be made without flattening, kinking, rippling or destroying the smooth internal bore or surface of the conduit and to not less than NEC minimum radius. Conduit that shows signs of rippling or kinking shall not be installed. Conduits installed with wrinkles or kinks or otherwise in an unworkmanlike manner shall be replaced at no additional cost to owner.

D. Precaution shall be exercised to prevent accumulation of water, dirt or concrete in the conduits during the execution of the project. Conduits in which water or foreign matter has been permitted to accumulate shall be thoroughly cleaned or the conduits runs replaced where such accumulation cannot be removed by methods approved by the engineer.
E. Any conduit which pierces airtight spaces or plenums shall be sealed to prevent air leakage with mastic acceptable to the Architect.

1.10 CONCEALING:
A. All raceways shall be concealed within the ceilings, walls, and floors, except in locations where exposed raceways are specifically permitted, such as equipment rooms and unfinished storage areas. In equipment rooms, if lighting raceways are run exposed, installation shall not be done until piping and duct work layout has been determined in order that lighting boxes may be located so as to avoid being covered by overhead ducts and piping. If lighting raceways in equipment rooms are concealed in the structural ceiling slab, after mechanical work is complete, exposed conduit extensions shall be run to locate lighting fixtures where they are not obscured by work of other trades.

1.11 BURIED CONDUITS:
A. Comply with all burial depths as defined in NEC Section 300-5. Bury all conduits at least 24” below grade, unless specifically indicated otherwise on drawings. Provide magnetic 6” wide “Yellow Warning” ribbon 12” directly above conduit and 6” below finished grade measured from the top of the conduit or duct bank. Where multiple small lines are buried in a common trench and do not exceed an overall width of 16”, install a single marker.
B. Slope all conduits toward manholes or pull boxes for proper drainage. Use weep holes. Gravel drainage pockets are not permitted.
C. Coat all metal conduits with an approved asphaltic compound or wrap with two layers of PVC tape.
D. Under Concrete Slab on Grade: Horizontal conduit must be installed a minimum of 8” below the bottom of the concrete slab. Conduits should not be installed in concrete slabs.
E. Concrete Encasement: Where concrete-encasement is indicated on drawings, provide duct bank construction using red 3000 psi at 28 day strength concrete. Provide minimum 4” cover on all sides of exterior conduits. Provide conduit spacers where applicable. Coat all metal conduits with an approved asphaltic compound or wrap with two layers of PVC tape.
F. Where conduits are extended for future use, cap and clearly mark.

1.12 ELECTRICAL CONTINUITY:
A. Provide electrically continuous conduit systems throughout.

1.13 FIELD CUTS AND THREADS:
A. Cut all conduits square. Remove all sharp or rough edges and ream all burrs, inside and outside. Provide clean sharp threads on RMC and IMC.
B. Engage at least five full threads on all RMC and IMC fittings. Before couplings or fittings are attached, apply one coat of red lead or zinc chromate to male threads of RMC or IMC. Apply coat of red lead, zinc chromate or special compound recommended by manufacture to conduit where conduit protective coating is damaged.

1.14 SUSPENDED SLABS:
A. Not allowed in horizontal suspended slabs, but may pass through vertically.
CONDUIT ENDS:

A. Cap all spare conduits. Cap or plug conduit ends during construction to prevent entrance of foreign material.

SPARE CONDUITS:

A. Provide five (5) 3/4" empty conduits from recessed branch panelboards to accessible ceiling spaces and five (5) 3/4" conduits into accessible floor space. When floor is not accessible, provide six (6) 3/4" empty conduits from panelboard to accessible ceiling space. Cap and label all conduits.

B. Install a 200 lb. polypropylene pull cord in each empty conduit run.

POWER COMPANY RACEWAY METHODS:

A. Comply with all Power Company Requirements.

B. The contractor shall provide all conduit systems for the required electrical utility work; raceway shall be PVC or RMC. All elbows shall be long-radius PVC, RMC, or fiberglass elbows complying with all ESR requirements. Sleeve conduits when conduit extends vertically through a paved surface. Provide 500 lb flat pull line or poly rope within each conduit. Proof all conduits with an 80% diameter mandrel witnessed by the Utility representative.

C. The contractor shall provide trenching, boring, backfill, compactions, and surface repair.

D. The contractor shall provide pre-case concrete pad/vaults for utility provided transformers as required.

E. The contractor shall provide concrete pads for utility provided transformers as required.

F. Install RMC and IMC in all hazardous locations as defined by the NEC. Provide suitable fittings, seal-offs, boxes, etc. to comply with all NEC requirements and/or as shown on the drawings. Provide inspection fittings with hazardous location rated drains to prevent water from accumulating in conduit runs.

HAZARDOUS LOCATIONS:

A. Install RMC and IMC in all hazardous locations as defined by the NEC. Provide suitable fittings, seal-offs, boxes, etc. to comply with all NEC requirements and/or as shown on the drawings. Provide inspection fittings with hazardous location rated drains to prevent water from accumulating in conduit runs.

CLEANING:

A. Pull mandrel and swab through all conduits before installing conductors.

RACEWAYS FOR BUILDING AUTOMATION SYSTEM:

A. The successful Division 26 Contractor will be required to provide all raceways and outlet boxes for the building automation system in accordance with Division 25 and this specification. The cost for the raceways shall be carried under Division 25. Coordinate all work with Division 25.

END OF SECTION 26 0110
PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to conductors and cables.

1.2 DESCRIPTION OF WORK:

A. This section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

B. Types of conductors and cables in this section include the following:

1. Copper Conductors.
2. Aluminum Conductors.
3. MC Flexible Metal Clad Copper Cables.
4. Flexible Cords.

C. Applications for conductors and cables required for project include:

1. Electrical service.
2. Feeders.

1.3 SUBMITTALS:

A. Product Data: For each type of conductor and/or cable indicated.

B. Field Quality-Control Test Reports: From Contractor. Refer to Section 26 0001 – General Electrical Provisions.

1.4 QUALITY ASSURANCE:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 – PRODUCTS

2.1 GENERAL:
A. Manufacturers: In other Part 2 articles where subparagraph titles below introduce lists, provide products by the manufacturer specified, subject to compliance with requirements.

B. Ambient Conditions: Conductors used for branch circuits in areas where the ambient conditions exceed 30 degree C. shall be provided with insulation approved for that temperature.

C. Wire Sizes: As indicated on electrical drawings or as specified herein, but in no case less than No. 12 AWG.

2.2 COPPER CONDUCTORS:

A. Manufacturers:
   1. Cerro Wire & Cable Company.
   2. General Cable Technologies Corporation.

B. Refer to Part 3 "Conductor and Cable Applications" Article for application requirements.

C. References and Ratings:
   1. ICEA S-95-658 / NEMA WC70.
   2. ASTM.
   3. UL Standard 83.
   4. UL Standard 1063 (MTW).
   5. Federal Specification J-C-30B.
   6. NEC.

D. Conductor Material: Copper.

E. Stranding: Solid conductor for No. 12 AWG, stranded for No. 10 AWG and larger.

F. Conductor Insulation Types: Thermoplastic-insulated, Type THHN / THWN-2.

2.3 ALUMINUM CONDUCTORS:

A. Manufacturers:
   1. Alcan Aluminum Corporation; Alcan Cable Div.

B. Refer to Part 3 "Conductor and Cable Applications" Article for application requirements.

C. References and Ratings:
   1. ICEA S-95-658 / NEMA WC70.
   2. Federal Specification J-C-30B.
   3. ASTM Standards B 800 and B 801.

D. Conductor Material: Aluminum.

E. Stranding: STABILOY compact stranded conductor (AA-8000 Series aluminum alloy).

F. Conductor Insulation Types: Black cross-linked polyethylene (XLPE), Type XHHW-2.
2.4 MC FLEXIBLE METAL CLAD COPPER CABLES:

A. Manufacturers:
   1. AFC Cable Systems, Inc.

B. Refer to Part 3 "Conductor and Cable Applications" Article for application requirements.

C. References and Ratings:
   1. UL 83, 1479, 1569, 1581, File Reference E80042.
   2. NEC 230-43, 300-22(c), 318, 321, 334, 518, 520, 530, 645.
   3. Federal Specifications J-C-30B.
   4. Meets all applicable OSHA and HUD requirements.
   5. May be surface-mounted or embedded in plaster.
   6. UL rated for Cable Tray and Environmental Air-Handling Space installation; 1, 2 and 3-hour through-penetration Fire Wall rated.

D. Conductor Material: Copper.

E. Stranding: Solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.

F. Conductor Insulation Types: Type THHN.

G. Armor: Galvanized steel.

H. Assembly Covering: Mylar Tape.

I. Grounding: Insulated green grounding conductor.

2.5 FLEXIBLE CORDS:

A. Manufacturers:
   1. Cerro Wire & Cable Company.
   2. General Cable Technologies Corporation.

B. Refer to Part 3 "Conductor and Cable Applications" Article for application requirements.

C. References and Ratings:
   1. ASTM.
   2. ICEA.
   3. UL 62.
   4. Pendant or portable.
   5. Damp locations.
   6. 600 Volts.
   7. NEC Article 400.

D. Conductor Material: Copper.

E. Stranding: Class K, flexible stranded conductor.
F. Conductor Insulation Types: Heat- and moisture-resistant TPE insulation.

G. Fillers and Wrapping: Non-wicking polypropylene fillers, with tissue-paper separator wrapped around the assembly.

H. Outer Jacket: Black-colored, heat-, moisture-, and oil-resistant TPE jacket.

I. Grounding: Insulated green grounding conductor.

J. Cord Type: SO, hard-usage.

2.6 CONNECTORS AND SPLICES:

A. Manufacturers:
   1. AFC Cable Systems, Inc.
   2. AMP Incorporated/Tyco International.
   3. Hubbell/Anderson.
   4. O-Z/Gedney; EGS Electrical Group LLC.
   5. 3M Company; Electrical Products Division.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. Splices for wire sizes #10 and smaller shall be screw-on type similar to scotch or ideal wing nut connectors. Crimp-on splices designed to be used without wire stripping are not acceptable.

PART 3 – EXECUTION

3.1 GENERAL:

A. Install conductors, cables, and accessories as indicated, in compliance with manufacturer's written instruction, applicable requirements of NEC, NECA's "Standards of Installation", and in accordance with recognized industry practices to ensure that products fulfill requirements.

3.2 CONDUCTOR AND CABLE APPLICATIONS:

A. Service Entrance: As indicated on the electrical drawings.

B. Feeders: As indicated on the electrical drawings.

C. Branch Circuits:
   1. Exposed, including in crawlspaces: Copper conductors in raceway. In finished ceiling areas, conduits shall be painted to match the surrounding surface.
   2. Concealed in gypsum board ceilings, walls, and partitions: Copper conductors in homerun raceways from electrical panelboards to first outlet box; MC flexible metal clad copper cables are allowed for connection of wiring devices, light fixtures, and equipment at load end and in dry and concealed locations only. MC cables are not allowed in CMU or concrete walls. The maximum run on any one MC cable to limited to 15 feet.

E. Class 1 Control Circuits: Copper conductors in raceway.

3.3 INSTALLATION:

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. 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.

C. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

D. When raceway is not required, install concealed cables parallel and perpendicular to surfaces of structural members, and follow surface contours where possible.

E. Support cables according to other applicable specification sections.

F. Seal around cables penetrating fire-rated elements to comply with applicable fire stop specification sections.

G. Color Coding: Color code secondary service, feeder, and branch circuit conductors. Colors shall remain consistent throughout the project and shall match existing coding system where applicable.

1. Conductor sizes No. 6 AWG and smaller: Colored insulation.
2. Conductors sizes No. 4 AWG and larger: 2-inch (51 mm) band of Colored adhesive marking tape applied at all terminations, junction boxes, and pull boxes.
3. Branch circuit switched-legs and travelers: Colored insulation (in colors other than those indicated below).
4. Color-code 120/208V system conductors:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   e. Neutral B: White with Red stripe.
   f. Neutral C: White with Blue stripe.
   g. Neutral (Shared when allowed): White
   h. Ground: Green.
   i. Isolated Ground: Green with yellow tracer.
5. Color-code 277/480V system conductors:
   b. Phase B: Orange.
   c. Phase C: Yellow.
   e. Neutral B: Gray with Orange stripe.
   f. Neutral C: Gray with Yellow stripe.
   g. Neutral (Shared when allowed): Gray.
   h. Ground: Green.

3.4 HOMERUN CIRCUITS:

A. Homerun circuits may be combined in common conduits at the option of the contractor in compliance with the following:
1. Three-Phase Installations: Not more than three single-phase circuits in one conduit, unless specifically noted otherwise, if each circuit is from a different phase (a, b, or c).

3.5 NEUTRAL CONDUCTORS:

A. LINE-TO-NEUTRAL BRANCH CIRCUITS: For multi-phase branch circuits, provide an oversized common neutral conductor sized one size (AWG) larger than the largest phase conductor. For 120/208V, 3-Phase systems, provide UL-Listed common handles. For 277/280V, 3-Phase systems, provide multi-pole circuit breakers.

3.6 VOLTAGE DROP:

A. Provide branch circuit conductors in sizes such that voltage drop for branch circuits do not exceed 3 percent at the farthest outlet. Provide service, feeder, and branch circuit conductors so that the voltage drop on the entire electrical system does not exceed 5 percent at the farthest outlet. This shall be strictly followed regardless of the conductor sizes indicated on the electrical drawings. Increase conductor sizes (and conduits where necessary to comply with NEC conduit fill requirements) as necessary to accommodate this requirement. Calculations shall be based on the following:

1. Lighting Branch Circuits: Connected load plus 25% spare.
2. Appliance and Equipment Branch Circuits: Nameplate or NEC required load.
3. 120V Convenience Outlet Branch Circuits: 12 amps minimum, but in no case less than NEC loading requirements. Use the following schedule:

<table>
<thead>
<tr>
<th>Distance (feet)</th>
<th>Wire Size (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-80</td>
<td>#12</td>
</tr>
<tr>
<td>81-125</td>
<td>#10</td>
</tr>
<tr>
<td>126-200</td>
<td>#8</td>
</tr>
<tr>
<td>201-320</td>
<td>#6</td>
</tr>
</tbody>
</table>

4. Use the NEC method to calculate voltage drop.

3.7 CONNECTIONS:

A. All connections shall be made using a torque wrench. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B. Provide a report indicating the actual torque values utilized on all feeders 100 amp and greater.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

D. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack. Use pig tails when wiring outlets.

3.8 FIELD QUALITY CONTROL:

A. Testing: Perform the following field quality-control testing:

1. Visual and Mechanical Inspection:
   a. Inspect cables for physical damage and proper connection in accordance with
the electrical construction documents.

b. Test cable mechanical connections to manufacturer’s recommended values with a calibrated torque wrench.

c. Check cable color coding for compliance with electrical specifications.

2. Electrical Tests:
   a. Perform insulation resistance test on each conductor for feeders 100 amps and greater with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
      i. Follow-up insulation resistance test: Perform an additional follow-up insulation test for each conductor for feeder 100 amps and greater with respect to ground and adjacent conductor. Applied potential shall be 1000 volts dc for 1 minute.
      ii. An Owner’s representative shall witness the tests. Coordinate schedule of testing and power outages with the Owner at least two weeks prior to testing.

b. Perform continuity test to insure proper cable connection.

3. Test Values:
   a. Minimum insulation resistance values shall not be less than two megaohms.

4. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
   d. An Owner’s representative shall witness the tests. Coordinate schedule with Owner at least two weeks prior to testing.

B. Test Reports: Prepare a written report and submit to the Electrical Engineer at the completion of the project. The report shall include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 0120
SECTION 26 0135
ELECTRICAL BOXES AND FITTINGS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to electrical boxes and fittings.

1.2 DESCRIPTION OF WORK:

A. Extent of electrical boxes and fittings work is indicated by drawings and schedules.

B. Types of electrical boxes and fittings in this section include the following:

1. Outlet Boxes
2. Junction Boxes
3. Pull Boxes
4. Floor Boxes
5. Conduit Bodies
6. Bushings
7. Locknuts
8. Knockout Closures
9. Miscellaneous Boxes and Fittings

1.3 QUALITY ASSURANCE:

A. Standards: Refer to Section 26 0001 – Electrical General Provisions as applicable.

B. Manufacturers: Firms regularly engaged in the manufacturer of boxes and fittings required, whose products have been in satisfactory service for not less than three years.

C. Shop Drawings: Submit shop drawings on floor boxes only where required.

PART 2 – PRODUCTS

2.1 INTERIOR OUTLET BOXES:

A. General: Provide one piece, galvanized or cadmium-plated, flat-rolled, sheet steel interior outlet boxes of types, shapes, and sizes to suit respective location and installation. Construct with stamped knockouts on back and sides and with threaded screw holes. Provide corrosion-resistant screws for securing boxes, covers, and wiring devices. Size all junction boxes in accordance with NEC Table 314.16(A), with a minimum box size of 4” x 4” x 1-1/2”. Where three raceway entries are made, provide outlet boxes with a minimum depth of 2-1/8”. Where four or more raceway entries are made, provide outlet boxes with a minimum depth of 4-11/16”.

Ellis Elementary School 26 0135 - 1 ELECTRICAL BOXES AND FITTINGS
Gangable boxes shall not be used.

B. Switch, Telephone, and Receptacle Outlets: Provide outlet boxes not less than 4” square, with adapting tile or plaster covers where necessary to set flush with finished surfaces. Where three raceway entries are made, provide outlet boxes with a minimum depth of 2-1/8”. Gang boxes shall be used where more than one switch or device is located at one point. Sectional Boxes are not acceptable. In masonry walls where tile or plaster ring cannot be used, install a single-gang 3-1/2” deep box minimum, unless otherwise noted. Where four or more raceway entries are made, provide outlet boxes with a minimum depth of 4-11/16”.

C. Lighting Outlets:
   1. Lay-in Grid: Outlets for recessed fixtures in acoustical tile ceilings shall be located to center on a single tile or at the intersection of four tiles.
   2. Surface-mounted: Provide 4” square octagonal outlet boxes for surface-mounted, ceiling fixture outlets. Mount each box independently of the conduit on standard 3/8” stud or approved box hangar where applicable. Include backing and supports as required to carry 200 lbs. Where three or more raceway entrances are made, use a minimum box depth of 2-1/8”.

2.2 WEATHERPROOF OUTLET BOXES:
   A. Provide corrosion-resistant, cast-metal weatherproof outlet boxes, of types, shapes, and sizes, with threaded conduit ends, cast metal coverplates with spring-hinged waterproof caps, face plate gaskets, and corrosion-resistant fasteners.

2.3 JUNCTION AND PULL BOXES:
   A. Provide code-gauge sheet steel junction and pull boxes, with removable screw-on covers and welded seams, of types, shapes, and sizes to suit each respective location and installation. Size all junction and pull boxes in accordance with NEC 314.28. Provide stainless steel nuts, bolts, screws, and washer.

2.4 FLOOR BOXES:
   A. Provide steel or PVC, weatherproof, concrete-tight floor boxes of types, shapes, and sizes to suit each respective location and installation. Where multi-service floor boxes are indicated, provide floor boxes sized to accommodate wiring devices and communication outlets shown on drawings. Construct floor boxes with fully adjustable leveling screws, and knockouts as required to accommodate specified conduits.

   B. Provide floor boxes from the following manufacturers:
      1. Bell Electric
      2. Crouse-Hinds
      3. Hubbell
      4. Steel City
      5. Thomas&Betts
      6. Wiremold

2.5 CONDUIT BODIES:
   A. Provide galvanized, cast-metal conduit bodies of type, shapes, and sizes to suit respective locations and installation. Construct with threaded conduit entrance ends and removable covers. Provide corrosion-resistant screws.
B. Aluminum boxes and fitting shall not be permitted.

2.6 CONDUIT CONNECTIONS:

A. Box connectors 3/4" and larger shall be insulated, throat-type or equal type plastic bushings. Provide double locknuts and insulating plastic bushings for RMC and IMC terminating at panels and boxes.

B. Where RMC penetrates building, manholes, or vault walls and floors below grade, provide sealing bushings with external membrane clamps as applicable. Provide segmented internal sealing bushings in all raceways penetrating building walls and slabs below grade, and in all above grade raceway penetrations susceptible to moisture migration into building through raceway. Where RMC terminates in manhole, vault, or pull box, provide insulated grounding bushings.

C. Install OZ type "B" connectors for all conduits 1" and larger.

D. Provide cable supports in all vertical risers in accordance with NEC 300-19.

2.7 EXPANSION FITTINGS:

A. Provide expansion joint fittings in all conduit runs crossing structural expansion joints, whether above-grade, in slab-on-grade, or in suspended slabs. Provide OZ type "AX" or approved equivalent, size to the raceway.

2.8 ACCESSORIES:

A. Provide all accessories including, but not necessarily limited to, bushings, knockout closures, locknuts, offset connectors, etc. of types, shapes, and sizes to suit respective locations and installation. Construct of corrosion-resistant steel.

PART 3 – EXECUTION

3.1 GENERAL:

A. Install electrical boxes and fittings in accordance with manufacturer’s written instruction, applicable requirements of the NEC, NEMA Standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 METHODS:

A. Where outlet boxes are subject to weather or moisture, install weatherproof outlet boxes.

B. Remove knockouts only for entering conduits. Provide knockout closures to cap unused knockout holes where blanks are mistakenly removed.

C. Do not use condulets in place of elbows or junction boxes. Condulets in sizes 2" or larger shall not be used, unless specifically approved by the electrical engineer.

D. Install boxes and conduit bodies in readily accessible locations. Install recessed boxes with faces of boxes or rings flush with finished surfaces. Seal all openings between outlet box and adjacent surfaces with plaster, grout, or similar suitable material.
E. For stud construction, install boxes with rigid supports using metal bar hangers, or 2" X 4", 1" X 6" wood bridging between studs with screws. Welding or nailing boxes directly to metal joist and studs is not acceptable. Boxes set opposite in common wall shall have at least 10" of conduit between them. Securely fasten outlet boxes to structural surfaces to which attached.

F. For concrete or masonry construction, solidly embed electrical boxes in concrete and masonry. Provide box supports as required to keep outlet boxes flush with finished surfaces.

G. Coordinate location of all outlet boxes with millwork, back splashes, tackboards, etc.

H. Install junction boxes or condulets in conduit runs as required at 100 foot maximum intervals on long runs. This shall apply to concrete junction boxes in grade and junction boxes within the building.

I. Provide electrical connections for installed boxes.

3.3 IDENTIFICATION:

A. Mark circuit number on exterior side of junction boxes located in ceilings such that circuit numbers are readily identifiable. For outlet boxes in wall, mark circuit numbers on interior sides of outlet boxes.

B. In each outlet, tag each wire to identify which circuit it serves. Label outlet boxes and inside of covers with circuit and panel numbers in permanent marker.

C. Identification labels shall be as follows:

- Normal Power: Black with White letters
- Emergency Power: Red with White Letters

END OF SECTION 26 0135
1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to wiring devices.

1.2 DESCRIPTION OF WORK:

A. Extent of wiring device work is indicated by drawings and schedules.

B. Types of electrical wiring devices in this section include the following:

1. Toggle Switches
2. Receptacles
3. Floor Service Outlets
4. Poke-Through Assemblies
5. Special Purpose Outlets
6. Cord Caps and Connectors

1.3 QUALITY ASSURANCE:

A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.

B. SHOP DRAWINGS:

1. Submit manufacturer's data on all electrical wiring devices.
2. Where occupancy sensors are required, provide scaled drawing showing manufacturer's recommended locations.

PART 2 – PRODUCTS

2.1 GENERAL:

A. Provide factory-fabricated wiring devices, in types, and electrical ratings for applications indicated and complying with NEMA standards Pub No. WD 1; nylon construction, 20 amp rating minimum.

B. Provide wiring devices in colors selected by Architect/Engineer. Provide red receptacle outlets where devices are circuited to emergency or standby power.

2.2 TOGGLE SWITCHES:
A. Provide toggle switches from one of the following manufacturers:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>1-Pole</th>
<th>3-Way</th>
<th>4-Way</th>
<th>W/Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>HBL1221</td>
<td>1223</td>
<td>1224</td>
<td>1221-PL</td>
</tr>
<tr>
<td>Pass &amp; Seymour</td>
<td>20AC1</td>
<td>20AC3</td>
<td>20AC4</td>
<td>20AC1-RPL</td>
</tr>
<tr>
<td>Leviton</td>
<td>1221</td>
<td>1222</td>
<td>1223</td>
<td>1221-PLR</td>
</tr>
<tr>
<td>Cooper</td>
<td>2221</td>
<td>2223</td>
<td>2224</td>
<td>2221-PLR</td>
</tr>
<tr>
<td>Bryant</td>
<td>4901</td>
<td>4903</td>
<td>4904</td>
<td>4901-PL</td>
</tr>
</tbody>
</table>

B. Abbreviations are defined as follows:

1. 1-Pole - Single-Pole Toggle Switch
2. 3-Way - Three-Way Toggle Switch
3. 4-Way - Four-Way Toggle Switch
4. W/Pilot - Single-Pole Toggle Switch with Pilot Light

C. Must be back and side wired, and have color-coded covers, Brass terminal screws, back wire ground clamp, and self-grounding clip.

2.3 RECEPTACLES:

A. Provide heavy-duty, straight-blade, tamper-resistant, specification-grade, 20-amp duplex receptacles from one of the following manufacturers:

<table>
<thead>
<tr>
<th>Basis-of-Design Manufacturer</th>
<th>CO</th>
<th>GFCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>HBL5362_TR</td>
<td>GFTRST20_</td>
</tr>
</tbody>
</table>

Equivalent products from Pass & Seymour and Cooper are also acceptable.

B. Where duplex receptacles are shown with an “H” subscript on the electrical drawings, provide heavy-duty, straight-blade, tamper-resistant, specification-grade, hospital-grade, 20-amp duplex receptacles from one of the following manufactures:

<table>
<thead>
<tr>
<th>Basis-of-Design Manufacturer</th>
<th>CO</th>
<th>GFCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>8300_TRA</td>
<td>GFTRST83_</td>
</tr>
</tbody>
</table>

Equivalent products from Pass & Seymour and Cooper are also acceptable.

C. Where duplex receptacles are shown with an “USB” subscript on the electrical drawings, provide USB-charger (Types A & C), straight-blade, tamper-resistant, specification-grade, hospital-grade, 20-amp duplex receptacle from one of the following manufactures:

<table>
<thead>
<tr>
<th>Basis-of-Design Manufacturer</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubbell</td>
<td>USB8300AC5_</td>
</tr>
</tbody>
</table>

Equivalent products from Pass & Seymour and Cooper are also acceptable.

D. Abbreviations are defined as follows:

1. CO- Convenience Outlet Duplex Receptacle
2. GFCI- Ground Fault Circuit Interrupter duplex Receptacle

E. Must have one-piece Brass back strap and back wire grounding clamp (Does not apply to GCFI type devices).

2.4 FLOOR SERVICE OUTLETS:

A. Provide all receptacles and special purpose outlets required in floor boxes. See Section 26 0135 – Electrical Boxes and Fittings. Provide coverplates, carpet flanges, etc. in finishes or colors selected by Architect/Engineer.

2.5 POKE–THROUGH ASSEMBLIES:

A. Provide factory-assembled, poke-through assemblies equipped with wiring devices as specified herein. Construct of materials to maintain fire rating of suspended slab with pre-wired conduit, fire barriers, toggle arm assemblies, service fittings, integral junction box, etc. Provide coverplates, carpet flanges, etc. in finishes or colors selected by Architect/Engineer. Provide Poke-through assemblies of one of the following:

1. Hubbell
2. Thomas&Betts
3. LeGrande, Wiremold

2.6 SPECIAL PURPOSE OUTLETS:

A. Provide special purpose outlets of voltage and ampere ratings, and NEMA configurations to suit respective application. Refer to drawings for NEMA configuration. Provide special purpose outlets in amperages at least as large as the overcurrent protective device from which they are served.

2.7 CORD CAPS AND CONNECTORS:

A. Provide cord caps and connectors of voltage and ampere ratings, and NEMA configurations which mate and match with outlets specified as required for final connections for equipment. Provide cord caps and connectors of one of the following:

1. Hubbell
2. Pass & Seymour
3. Leviton
4. Cooper

2.8 COVERPLATES:

A. Wall Plates: Provide coverplates for all wiring devices. In all finished areas, provide stainless steel coverplates. Provide ganged coverplates for all switches and/or dimmers. Provide pre-marked coverplates for special purpose outlet indicating voltage, amperages, and phase. Provide raised stamped, galvanized, steel plates in all unfinished areas. Provide weather-proof coverplates for outlets exposed to weather and moisture.

B. Weather-Protecting Device Enclosure: Where required for compliance with NEC 410-67 (receptacles installed outdoors for use other than with portable tools or equipment), provide weather-tight device covers which provide complete protection with the cord and cap inserted into the wiring device. Provide units which mount on either single or double gang devices. Provide device enclosures manufactured by one of the following:
1. Intermatic WP1020 or WP1030
2. Hubbell WP826MP
3. Pass & Seymour

PART 3 – EXECUTION

3.1 GENERAL:
A. Install wiring devices and accessories in accordance with manufacturer’s written instruction, applicable requirements of the NEC, NEMA Standards, and NECA’s “Standards of Installation”, and in compliance with recognized industry practices to insure that products fulfill requirements.

3.2 METHODS:
A. Install wiring devices only in electrical boxes which are clean and free from excess building materials, dirt, and debris. Do not install wiring devices until painting work is completed.
B. Replace receptacles and/or coverplates which are damaged, stained, or burned.

3.3 GFCI RECEPTACLES:
A. Provide separate neutral conductor from panel to each GFCI receptacle circuits.
B. Install GFCI receptacles for all receptacles installed in restrooms, outdoors, or within six feet of any sink. All receptacles in kitchens shall be GCFI protected.
C. Do not wire standard receptacles on the load side of GFCI receptacle - Install GFCI receptacles.

3.4 DIMMERS:
A. Provide separate neutral conductor for each phase of the branch circuit on which dimmers are installed.
B. Provide dimmers in wattage ratings that will support the maximum potential wattage of the fixtures that are being dimmed. Do not size dimmers based on actual lamps installed in light fixtures, but on maximum lamp wattage ratings of light fixtures on that particular circuit.
C. Provide dimming leads to all LED light fixtures that have that 0-10 V dimming capabilities.

3.5 GROUNDING:
A. Provide electrical continuous, tight, grounding connections for wiring devices.

3.6 TESTING:
A. Prior to energizing circuitry, test wiring devices for electrical continuity and proper polarity connections. After energizing circuitry, test wiring devices to demonstrate compliance with requirements.

3.7 IDENTIFICATION:
A. All devices shall be identified on the cover plate with the panel board name and the circuit number by a black on clear adhesive label.
B. In each outlet, tag each wire to identify the circuit it serves.

END OF SECTION 26 0140
PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to motor starters.

1.2 DESCRIPTION OF WORK:

A. Extent of motor starter work is indicated by drawings and schedules.

B. Type of motor starters in this section include the following:

1. Fractional Horsepower Manual Starters
2. Non-Reversing Magnetic Starters
3. Combination Non-Reversing Magnetic Starters

1.3 QUALITY ASSURANCE:

A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.

B. SUBMITTALS:

1. Shop Drawings: Submit manufacturer's data and dimensional details on motor starters including voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

2. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of products.

PART 2 – PRODUCTS

2.1 GENERAL:

A. Manufacturers: Subject to compliance with all requirements, provide products of on of the following:

1. Allen Bradley
2. Eaton Cutler-Hammer
3. General Electric
4. Siemens
5. Square D
B. Maintenance, Stock, Fuses: For types and ratings required, furnish additional fuses, amounting to one unit for every 10 installed units, but not less than 3 units of each, for both power and control circuit fuses.

2.2 THERMAL OVERLOAD UNITS:

A. Provide metal alloy, thermal overload units for all motor starters. Size to actual running full load current, not to motor plate current, after air and water balancing are completed.

2.3 FRACTIONAL HORSEPOWER MANUAL STARTERS:

A. Provide fractional horsepower manual starters for single-phase fractional horsepower motors up to and including 1 horsepower, equivalent to Square D Class 2510, Type F, of types, sizes, and electrical characteristics required to suit applications or as otherwise indicated on drawings. Provide NEMA ICS 2, AC general-purpose Class A manually operated, full-voltage starter, with thermal overload units, red pilot light, and toggle operator with handle guard/lock-off. Provide ANSI/NEMA ICS 6, Type 1 enclosures, or where subject to weather or moisture, Type 3R.

2.4 NON-REVERSING MAGNETIC STARTERS:

A. Provide non-reversing magnetic starters equivalent to Square D Class 8536, Type S, of types, sizes, and electrical characteristics as required to suit applications or as otherwise indicated on drawings. Provide NEMA ICS 2, AC general-purpose Class A magnetic starter for induction motors. Provide encapsulated coil with operating voltage compatible with control system (coordinate with Divisions 21, 22, and 23). Provide totally enclosed, double-break, silver-cadmium-oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring. Provide straight-through wiring with all terminals clearly marked. Provide NEMA ICS, melting alloy, interchangeable, overload relays with one-piece thermal unit construction and under voltage protection in all phases. Provide replaceable overload relay control circuit contacts. Thermal units shall be required for starter to operate. Provide NEMA ICS 2, 2 each normally open and closed, field convertible, auxiliary contacts in addition to seal-in contact. Provide rotary-type, hand-off-auto and reset switches, recessed pushbutton control. Provide red pilot light. Provide control power transformer in each motor starter with fused primary and secondary. Provide each magnetic starter with integral phase failure protection that will protect against phase loss, phase unbalance, phase reversal, and undervoltage. Provide ANSI/NEMA ICS 6, Type 1 enclosures, or where subject to weather or moisture, Type 3R.

2.5 COMBINATION NON-REVERSING MAGNETIC STARTERS:

A. Provide combination, non-reversing magnetic starters equivalent to Square D 8538, Type S (non-fusible and fusible disconnect switch type) and Square D 8539, Type S (motor circuit protector type), of types, sizes, and electrical characteristics as required to suit applications or as otherwise indicated on drawings. Provide non-reversing magnetic starters and/or two-speed non-reversing magnetic starters with features as noted above in the descriptions for “NON-REVERSING MAGNETIC STARTERS”. Where Combination Magnetic Starter/Motor Circuit Protector switches are specified, provide NEMA AB 1, circuit breakers with integral instantaneous magnetic trip in each pole. Provide circuit breakers with externally operable handles that give positive visual indication of ON-OFF positions with red and black color coding.

PART 3 – EXECUTION
3.1 GENERAL:
   A. Install motor starters in accordance with manufacturer's written instructions, applicable requirements of the NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices.

3.2 METHODS:
   A. Install overload units so catalog number is visible. Mount chart inside each starter indicating heater type, size, and ampere ratings available.
   
   B. Where sizes of starters, disconnect, fuses, motor circuit protectors, heaters, etc. are not indicated on drawings, size all equipment in accordance with manufacturer's written instructions.
   
   C. Submit with the record drawings a record of the motor amperage readings of each electrically-driven unit; show horsepower, full-load amps and service factor.

3.3 IDENTIFICATION:
   A. Provide 1/16" thick black plastic laminate labels with 1/4" high lettering on the exterior of each starter cabinet. Provide red plastic laminate label for starter supplied by emergency power. Include mechanical equipment designation, horsepower, voltage, full-load amps, and service factor of motor. Mark on interior cover the source of power by indicating the panel and circuit number.

3.4 MOTOR CONNECTIONS:
   A. Each motor shall be connected to the conduit with a length of flexible, seal-tight conduit (minimum of 18"), with proper type fittings. All motor supply circuits shall include a green ground conductor. Check for proper motor rotation on all motors or equipment.

END OF SECTION 26 0155
SECTION 26 0156
VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of this contract, including general and supplementary conditions and division 1 specification sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to variable frequency drives.

C. Information contained on the drawings and/or schedules shall detail the additional specific requirements for the Variable Frequency Drive (VFD) system equipment.

1.2 SCOPE OF WORK:

A. It is the intent of this specification to set the minimum acceptable requirements for the design, construction, installation, commissioning and vendor support requirements for the VFD systems herein specified.

B. The VFD installation and associated equipment coordination and interface shall be provided by the electrical contractor.

1.3 CODES AND STANDARDS:

A. The equipment supplied under this specification shall conform to the latest applicable codes and standards of the following:

1. NEC - (NFPA 70) - National Electric Code.
2. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
3. NEMA AB 1 - Molded Case Circuit Breakers.
4. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
5. ANSI C37 - Standards for Circuit Breakers, Switchgear, Relays, Substations and Fuses.
6. ANSI C57 - Distribution, Power, and Regulating Transformers.

B. The fully assembled VFD system shall carry the UL label certifying UL-508 standards. An equivalent safety labeling program by ETL or CSA documenting compliance with these industry standards shall be acceptable.

1.4 VENDOR QUALIFICATIONS:

A. All vendors supplying equipment and/or services under this specification, shall pre-qualify and be listed in section 1.5.

B. The electrical contractor shall coordinate and assume system responsibility and compatibility between the various approved supplier's equipment and services required to meet these specifications.

C. The electrical contractor shall be responsible for the coordination with qualified vendors of
equipment and services outside the scope of this specification (but required for the proper operation of the system) as listed in section 4.1.

D. Suppliers of VFD systems shall have a minimum of five (5) years of experience supplying and maintaining VFDs. Suppliers must have a local service center with a factory spare parts inventory and factory-authorized service technicians available twenty-four hours a day.

1.5 ACCEPTABLE SUPPLIERS:

A. The following VFD manufacturer's equipment have been pre-approved to meet the products section of this specification:

1. Mitsubishi through Energy Management Corporation
2. Yaskawa through Energy Management Corporation
3. ABB through Midgley-Huber Inc.

B. Vendors wishing to quote other VFD manufacturers and/or service companies must have prior written approval from the engineer. If not listed above, the vendor must apply to the engineer for approval 10 days prior to bid date showing a point by point compliance with the intention of this specification including actual test and documentation reports from previous projects for all services required on this project.

1.6 MATERIAL BOND:

A. A material supply bond is required covering the VFD system equipment and services provided by the vendor on this project. The bond shall assure that all requirements and provisions of this VFD specification are complied with.

1.7 SUBMITTALS:

A. The following information shall be included with the bid package:

1. VFD system and services bid bond.
2. Description of equipment and tests included in bid to meet power quality requirements of section 3.1.
3. Qualifications and name of engineering and technical persons responsible for support and warranty on this project.
4. Extended warranty/service contract bid per section above.

B. The following shall be included in the submittal package in the quantities required under the general provisions of this project:

1. Completed Data Sheet.
2. Set of outline drawings giving complete mounting and conduit entry and exit dimensions.
3. Set of complete electrical drawings for power and control wiring.
4. Manufactures literature giving detailed information of equipment being supplied including part numbers, model numbers and ratings.

C. The following compliance and approval forms shall be submitted for approval:

1. Sample installation approval form to comply with section 4.1.
2. Sample VFD system commissioning approval form to comply with 4.2A.
3. Sample VFD system training approval form to comply with 4.2B.
4. Sample VFD quality assurance program and sample factory test and certification report forms as required to meet section 2.5.
D. The following shall be included in the Operations and Maintenance Manual(s):

1. All information required under paragraph 1.7B.
2. Test certificates.
3. Warranty information.
4. A listing of service personnel responsible for warranty repairs.

PART 2 – PRODUCTS

2.1 GENERAL:

A. This portion of the specification outlines the overall fabrication, performance and functional requirements of VFDs supplied for positive speed control of standard NEMA design B induction motors.

B. It is the intent of this section to specify non-proprietary designs and hardware that assure modern "state of the art" equipment which provides a high level of performance and reliability for the greatest long term, total value to the owner.

C. Provide VFD systems compatible in every respect with motor it controls. Coordinate work with Divisions 21, 22, and 23.

2.2 SYSTEM DESCRIPTION:

A. The VFD system shall be supplied as a complete, pre-integrated, stand-alone package produced by a single manufacturer regularly engaged in the production of same and who maintains full system support responsibility.

1. The VFD system manufacturer shall integrate all components and equipment required to meet these specification features and functions as a single UL (or equivalent) labeled system. Vendors providing equipment requiring panel shop or job site modifications or additions that would not be valid under the original equipment manufacturer's (OEM's) safety labeling will not be acceptable.

2. Pre-integrated equipment shall include but not be limited to rectifier units, inverter units, control circuitry, operator interfaces, protective equipment, and other accessories and auxiliary items necessary to meet the highest standards for the type of service specified herein.

2.3 CONSTRUCTION:

A. SPACE and ENVIRONMENT:

1. All VFD system components shall be housed in a grounded, dead front, free-standing, or wall mounted NEMA 1 enclosure. The variable frequency drive inverter unit shall be mounted on a removable panel to facilitate maintenance. The VFD system size shall not exceed the size allotments specified on the drawings nor shall any portion of the system exceed a height of 90 inches. Entry shall be provided for incoming line and load cables as required or as shown on the drawings.

2. VFD systems mounted indoors shall be properly ventilated and sized to operate continuously at the job site elevation in an ambient environment of 0OC to 40OC, 0-90% RH. VFD systems mounted outdoors shall include environment control provisions as required (or as shown on the plans) to operate in an ambient of -30OC to 50OC, 0-100% RH.
3. Provide cooling fans in all variable frequency drive enclosures.

2.4 SUPPLY POWER:

A. All components of the VFD system shall be selected to operate continuously without any system trip or damage based on the nominal power specifications and requirements shown on the drawings or schedules. The above conditions must be maintained under the following expected variations:

1. Plus or minus 10% voltage fluctuation.
2. Plus or minus 3% frequency variation (5% if served by a back-up generator).
3. Distorted voltage waveform with up to 7% total voltage harmonic distortion.

B. The VFD system shall employ voltage sag ride-through coordination under normal operating (average load) conditions to prevent nuisance trips with the following utility interruptions (based on preliminary IEEE working group P1346 data):

1. 0% voltage for 1 cycle.
2. 60% voltage for 10 cycles.
3. 87% voltage continuous.

C. DEVICES and WIRING:

1. The VFD system shall employ door mounted industrial control operator devices, programming unit, and other devices per the layout shown on the drawings and as required to meet all functional and feature requirements of this specification. Operator pilot lights, switches and pushbuttons (if required) shall be industrial oil tight industry standard devices.
2. Control voltages shall be 120 volts or less supplied by machine tool type transformers employing both primary and secondary fusing. VFD control transformer VA sizes shall be increased by 10% or as necessary to accommodate external impedances when plans show connections to external safety interlocks or other control devices.
3. The VFD system factory wiring shall be permanently marked with hot emboss stamping or an equivalent marking system. All devices shall be labeled and identified with correct setting selections. All component identification and wiring shall be documented in the operation and maintenance manual.

D. LOAD:

1. The VFD system shall be capable of starting and continuously driving the specified maximum motor load as identified on the drawings and schedules.
2. VFDs driving variable torque loads shall be programmed to optimize load patterns which maximize system efficiency and minimize motor heating and stresses. VFDs driving constant torque or other loads shall be programmed to optimize load patterns for system or process performance as required.
3. All VFD systems shall have an overload capacity of a minimum of 120% for one minute.

E. EFFICIENCY and POWER FACTOR:

1. The VFD solid state converter and inverter power switching components and control shall be selected to achieve a 95% efficiency or better at full load and speed. Other auxiliary devices required on the drawings or in these specifications including cooling or heating devices etc. shall be of a design to optimize efficiency as intended under this specification.
2. The entire true system power factor (as measured at the input to the VFD system) shall
be 95% or better across the operational speed range. Power factor that becomes leading under light load conditions (due to PF correction) is acceptable only if voltage rise is prevented from back feeding to the rest of the system (meaning PF correction must act like a synchronous condenser). The voltage tolerance at the main VFD system input terminals (as specified in section 2.3 B1a.) shall not be compromised as a result of power factor correction techniques.

F. PROTECTION:

1. Short circuit protection shall be provided to the VFD system through an externally operated, door interlocked fused disconnect, circuit breaker or motor circuit protector (MCP) rated at 65,000 AIC minimum. The door interlocked handle must be capable of being locked off to meet NEC.

2. Overcurrent protection shall be provided in the VFD system through electronic motor overload (MOL) circuits with instantaneous trip, inverse time trip, and current limit functions. These shall be adjustable and optimized for the application. Multi-motor units shall have separate overload protection for every motor.

3. In addition to the overcurrent protection above, the VFD system shall provide over and under voltage protection, over temperature protection, ground fault protection, and control or microprocessor fault protection. These protective circuits shall cause an orderly shutdown of the VFD, provide indication of the fault condition, and require a manual reset (except under voltage) before restart. Under voltage from a power loss shall be set to automatically restart after return to normal. The history of the previous three faults shall remain in memory for future review.

4. External protective faults including safeties or motor over temperature may be interfaced to the VFD system and annunciated if shown on the drawings.

G. SYSTEM CONTROLS AND INTERFACE TERMINATIONS:

1. If shown on the drawings, the VFD system may require integrated transducers, controllers, sequencers, bypass methods, and communication interfaces among others. Such devices (shown on the drawings as part of the VFD system) shall be completely pre-integrated requiring the contractor to make only the typical field connections required as customer connections.

2. Items shown on the drawings or schedules as "future" shall be available from the VFD system manufacturer in kit form for future owner integration into the VFD system.

3. The VFD system customer terminations shall be clearly identified with terminal numbers and a permanent wiring diagram located in the VFD system enclosure.

4. The VFD shall be controlled with 0-10V dc (0 – 100% speed) and 4-20 ma (20 – 100% speed) signals. Coordinate all control work with Divisions 21, 22, and 23.

2.5 FEATURES:

A. The following operator control and indication features shall be provided standard (unless shown differently on the drawings) as part of each VFD system:

1. Hand-Off-Auto (local start at VFD, remote start with contact closure).
2. Local-Remote speed control (local speed control at VFD, remote speed control through speed reference signal).
3. Frequency (speed) indication.
5. Motor current indication.
6. VFD run indication.
7. VFD fault and diagnostic indication.
8. Bypass switch.
B. The following customer connections and interface terminations shall be provided standard (unless shown differently on the drawings) as part of each ASD system:

1. VFD remote start/stop connection.
2. External safeties connection.
3. VFD run annunciation.
4. VFD fault annunciation.
5. VFD speed reference input connection (4-20mA or as shown on drawings).

C. The following parameter adjustments shall be available to tune the VFD system:

1. Minimum and maximum speeds.
2. Acceleration and declaration times.
3. Overcurrent trip point.
5. Maximum base motor voltage.
6. Input speed reference signal gain and bias.
7. Output speed reference signal gain and bias.

D. The VFD shall be capable of starting into a rotating motor at any speed.

E. The VFD shall auto restart after a power failure.

F. For maintenance purposes, the VFD system shall be capable of starting, stopping, and running with stable operation with the motor completely disconnected (no load).

G. Provide bypass package consisting of the following equipment:

1. Extended enclosure.
2. Door interlocked motor circuit protector.
3. Electronic motor overload (Class 20 or 30).
4. 2 contactor bypass (output and bypass).
5. Fast acting drive input fuses.
   UL listed.

H. Provide 5% line reactors if recommended by the manufacturer based on size and type of unit.

2.6 QUALITY ASSURANCE:

A. The VFD system manufacturer shall have a quality assurance program acceptable to the engineer. An outline of this program shall be submitted for approval as noted in 1.7.

B. Prior to shipping any equipment, the manufacturer shall individually test and certify each unit to document compliance. This certification report shall be submitted as part of the operation and maintenance manual and include the following minimum testing:

1. A visual inspection shall be made consisting of all system components, wiring connections, and safety mechanisms.
2. High pot testing shall be conducted on the completed VFD system including all accessory power components as a complete package. This test shall be conducted per UL 508 (two times the rated voltage plus 1000 volts AC for 60 seconds) using regularly calibrated high pot test equipment.
3. A system run test shall be conducted using an actual motor accelerated and decelerated through the entire speed range.
4. All control panel devices, including switches, pilot lamps, keypad and special control devices shall be functional tested.
5. Special tests shown on the drawings or schedules or as later required by the engineer to demonstrate compliance with any specification herein shall be conducted upon request (either witnessed or not) at no additional cost.

PART 3 – EXECUTION

3.1 INSTALLATION:

A. The electrical contractor shall be responsible for mounting the VFD.

B. The VFD system equipment shall be installed and tested under the direction of factory trained personnel as specified in 1.2B & 4.2. The installation shall be certified based on the approval form submitted as part of section 1.7.

C. Protect stored VFD systems during construction. Storage must be in areas free of dirt, dust, vibration, and moisture. VFDs shall not be exposed to excessive heat or cold.

3.2 SYSTEM COMMISSIONING AND CERTIFICATION:

A. The VFD system start-up shall be performed by a service technician or engineer certified by the manufacturer. The following adjustments and tests shall be performed as a minimum with certified copies included in the maintenance and operation manual:

1. Verify that the input voltage is within the manufacturer's specification tolerances.
2. Verify that the motor rotation is correct in all modes of operation.
3. Verify all operator devices, programming and monitoring functions to be fully operational.
4. Verify operation of all field signal control connections.
5. Measure and record system output voltage and current at 50% and 100% speed. Tune the output voltage to correspond to motor nameplate rating at full speed. Check full load current measurements against nameplate data.
6. Make all parameter adjustments to tune and optimize the VFD system to the application. Record all configuration values as part of this report.

B. Owner training shall be provided for each model and type of VFD system provided. Training shall consist of both classroom and actual equipment hands-on training. The training shall be certified on the approved form (submittal required in section above) and included in the operation and maintenance manuals.

3.3 DOCUMENTATION:

A. The VFD system vendor shall supply certified as-built drawings based on the required drawings and approved drawing formats included as part of the submittal process (see section above).

1. The drawings shall be included as part of the operation and maintenance manual and be of a reproducible quality.
2. Autocad format files of each drawing shall also be included on a floppy disk.

B. The operation and maintenance manuals shall consist of the following instructions and information:

1. Unloading, handling, installation, and special consideration instructions.
2. Operating functional descriptions and operating instructions.
3. Bill of materials with all spare parts ordering information and availability.
4. Factory test reports per 2.5.
5. Start-up and system commissioning reports per 4.2A.
6. Training certification per 4.2B.

3.4 WARRANTY:

A. The VFD system vendor shall supply a complete parts and labor warranty (including travel expenses) for 1 year from the date of substantial completion.
   1. The warranty shall cover the entire VFD system including power devices, controllers, etc. enclosed as part of the system package.

B. In place of the one year warranty, a two year warranty/service contract shall be quoted as an option at bid time. This service contract shall be renewable in two year increments thereafter. The service contract shall be executable by the owner at the fixed bid price anytime during the first 6 months of operation from date of substantial completion.
   1. The extended warranty/service contract shall include necessary repairs or loaner replacement assuring complete restoration of operation within 24 hours from the time a service call is requested. A $200.00 per day penalty shall be applied for failure to comply after the acknowledged service request.
   2. The extended warranty/service contract shall include job site visits twice yearly to inspect, clean, tune (optimize parameters) and repair (if necessary) each ASD system supplied under this contract.
   3. The extended warranty/service contract shall include basic orientation and operator training review with the owner's designated personal as part of this visit.
   4. The extended warranty/service contract shall include a 200% performance bond in the owner's favor for the term of the service contract.

3.5 SOURCE QUALITY CONTROL:

A. All materials and equipment provided shall be new and unused.
B. All components shall be UL listed and labeled.
C. ASD shipped directly from the manufacturer shall have a UL label.
D. ASD packages assembled form components by suppliers shall be UL labeled or ETL approved.

END OF SECTION 26 0156
SECTION 26 0160
PANELBOARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
   A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
   B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to panel boards.

1.2 DESCRIPTION OF WORK:
   A. Extent of panel board work is indicated by drawings and schedules and is specified herein.
   B. Type of panel boards in this section include the following:
      1. Lighting and Appliance Panel boards
      2. Power Distribution Panel boards

1.3 QUALITY ASSURANCE:
   A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.
   B. SUBMITTALS:
      1. Shop Drawings: Submit dimensioned drawings of panel boards and enclosures showing accurately scaled layouts of enclosures. Include schedule of devices, including, but not necessarily limited to, circuit breakers, fusible switches, fuses, ground-fault circuit interrupters, and accessories.
      2. Equipment Room Layouts: Submit dimensioned drawings of all equipment rooms indicating spatial relationships to other proximate equipment. Insure that all code required clearances are maintained.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:
   A. Subject to compliance with all requirements, provide products from one of the follows:
      1. Eaton Cutler-Hammer
      2. General Electric Co.
      4. Square D Co.

2.2 GENERAL:
A. Provide panel boards, enclosures, and ancillary components, of types, sizes, and ratings indicated. Provide over current protective devices, etc. as indicated on drawings for a complete installation.

B. Where "Spaces" or "Blanks" are indicated on panel board schedules, provide drilled bus and mounting hardware ready to receive breaker or fusible switch of size indicated on panel board schedule.

2.3 PANELBOARD ENCLOSURES:

A. Provide Code gauge, galvanized or rust-resistant sheet steel enclosures in sizes and NEMA types to suit respective applications. The size of the wiring gutters and gauge of steel shall be in accordance with the latest NEMA Standards Publication and latest UL standards for panel boards. Flush locks shall not protrude beyond the front of the door. Key all enclosures alike and provide three keys at completion of the project. Fronts shall have adjustable indicating trim clamps, which shall be completely concealed when the doors are closed. Doors shall be mounted by completely concealed steel hinges. Provide door-within-door construction and front hinged to the enclosure. A circuit directory frame and card, with clear plastic covering shall be provided on the inside of the door. The directory cards shall be typewritten to identify each circuit service. Provide panel enclosures with doors hinged to enclosures. Provide ANSI-61 painted finish.

2.4 LIGHTING AND APPLIANCE PANELBOARDS:

A. Provide dead-front, safety-type lighting and appliance panel boards of types and electrical characteristic indicated. Provide aluminum bus bars, full-sized neutral bus, and ground bus. Provide insulated/isolated ground buses where indicated. Include overcurrent protective devices and switches in quantities, ratings, types, and arrangements shown. See Section 26 0180 – Overcurrent Protective Devices.

B. Rate devices, bussing, supports, etc. equal to or greater than the short circuit current rating indicated. Provide fully-rated systems only. Series-rated systems are not acceptable, unless specifically noted otherwise.

2.5 POWER DISTRIBUTION PANELBOARDS:

A. Provide dead-front, safety-type lighting and appliance panel boards of types and electrical characteristic indicated. Provide wall-mounted or floor-standing power distribution panelboards as indicated. Provide panel boards suitable for use as service equipment where required. Provide aluminum bus bars, full-sized neutral bus, and ground bus. Provide insulated/isolated ground buses where indicated. Include over current protective devices and switches in quantities, ratings, types, and arrangements shown. See Section 26 0180 – Overcurrent Protective Devices.

B. Rate devices, bussing, supports, etc. equal to or greater than the short circuit current rating indicated. Provide fully-rated systems only. Series-rated systems are not acceptable, unless

PART 3 – EXECUTION

3.1 GENERAL:

A. Install panel boards in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in
3.2 IDENTIFICATION:

A. Provide 1/16" thick black plastic laminate labels with 1/4" high lettering on both the interior and exterior of each panel board enclosure indicating name of panel board. Bolt and nut or rivet labels to enclosure. (Sheet metal screws are not acceptable).

B. All subpanels shall be labeled to identify the main panel that supplies the feeder circuit.

C. Provide red plastic laminate label for panel boards supplied by emergency power.

3.3 MOUNTING:

A. Mount panel boards as indicated, but in no case higher than 6'-6" from finished floor to top of panel. Anchor enclosures firmly to walls and structural surfaces.

B. Provide 4" high concrete pad under floor-standing power distribution panel boards.

3.4 CIRCUIT DIRECTORIES:

A. For lighting and appliance panel boards, provide typed panel board circuit directories. Indicate load description or name and location. Utilize actual building room numbers, not architectural room numbers used on drawings. Label the panel and circuit that feed this panel.

B. For power distribution panel boards, provide 1/16" thick black plastic laminate labels with 1/4" high lettering for each load served.

1. Provide red plastic laminate label for emergency loads.
2. If circuits are changed in a panel, type the new circuit designation and glue on existing circuit directory. Do not discard existing panel board schedule unless all circuits have been changed.

3.5 WIRING METHODS:

A. Arrange conductors neatly within enclosure, and secure with suitable nylon ties.

B. Panel boards shall not be used for junction or splicing boxes or as a raceway.

3.6 ARRANGEMENT OF OVERCURRENT PROTECTIVE DEVICES:

A. The over current protective devices shall be in the same sequence and labeled as the panel schedule on the drawings.

END OF SECTION 26 0160
PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to disconnect switches.

1.2 DESCRIPTION OF WORK:

A. Extent of disconnect switch work is indicated by drawings and schedules and is specified herein.

B. Type of disconnects in this section include the following:

1. Heavy Duty Disconnect Switches
2. Fusible Switches

1.3 QUALITY ASSURANCE:

A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.

B. SUBMITTALS:

1. Product Data: Submit manufacturer's data on disconnect switches including specifications, installation instructions, etc.
2. Shop Drawings: Submit dimensioned drawings of disconnects showing accurately scaled layouts of disconnects and enclosures.
3. Equipment Room Layouts: Submit dimensioned drawings of all equipment rooms indicating spatial relationships to other proximate equipment. Insure that all code required clearances are maintained.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with all requirements, provide disconnect switches (fusible and non-fusible) and fusible switches (in power panels) from one of the following:

1. Eaton Cutler-Hammer
2. General Electric
3. Siemens
4. Square D
2.2 **GENERAL:**

A. Provide fusible and/or non-fusible disconnect switches and ancillary components of types, sizes, ratings, and electrical characteristics as indicated. Provide enclosures in NEMA ratings suitable for applications. Provide fuses as indicated; See Section 26 0180 – Overcurrent Protective Devices.

2.3 **HEAVY DUTY DISCONNECT SWITCHES:**

A. Provide 600 volt rated, heavy duty switches in sheet steel enclosures as indicated of types, sizes, ratings, and electrical characteristics indicated and as required to suit respective application. Provide heavy duty switches for circuits rated greater than 240 volts, but less than 600 volts. Construct of spring-assisted, quick-make, quick-break mechanisms. Provide solid neutral as required by application. Equip with operating handle capable of being locked in the OFF position. Provide Class R rejection fuse clips for fusible-type switches.

2.4 **FUSIBLE SWITCHES:**

A. Provide factory-assembled, fusible switch units as integral components of distribution power panels and switchboards of types, sizes, ratings, and electrical characteristics indicated and as required to suit respective application. Provide quick-make quick-break mechanisms and visible blades. Equip with handle capable of being locked in the OFF position. Provide dual fuse door interlocks. Provide switch with Class R rejection fuse clips. Include copper lugs to accommodate conductors specified.

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**PART 3 – EXECUTION**

3.1 **GENERAL:**

A. Install disconnects in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Disconnects acting as main disconnecting means for photovoltaic system shall comply with all utility company requirements. Confirm all requirements prior to bid.

3.2 **IDENTIFICATION:**

A. Provide 1/16" thick black plastic laminate labels with 1/4" high lettering on the exterior of each disconnect indicating name of disconnect or load served. Bolt labels to enclosure. Mark on interior cover the source of power by indicating the panel and circuit number.

B. Provide red plastic laminate label for disconnects supplied by emergency power

3.3 **MOUNTING:**

A. Mount disconnects as indicated, but in no case higher than 6'-6" from finished floor to top of disconnect. Anchor enclosures firmly to walls and structural surfaces.

B. Provide 4" high concrete pad under floor-standing disconnects.

**END OF SECTION 26 0170**
SECTION 26 0180
OVERCURRENT PROTECTIVE DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 section making reference to over current protective devices.

1.2 DESCRIPTION OF WORK:
A. Extent of over current protective devices is indicated by drawings and schedules and is specified herein.
B. Type of over current protective devices in this section include the following:
   1. Molded Case Circuit Breakers
   2. Electronic Circuit Breakers
   3. Fuses

1.3 QUALITY ASSURANCE:
A. STANDARDS: Refer to Section 26 0001 - Electrical General Provisions as applicable.
B. SUBMITTALS:
   1. SHOP DRAWINGS: Submit manufacturer's data on overcurrent protective devices including specifications, time-current trip characteristics curves, mounting requirements, installation instructions, etc. Submit dimensioned drawings of overcurrent protective devices.
   2. Equipment Room Layouts: Submit dimensioned drawings of all equipment rooms indicating spatial relationships to other proximate equipment. Insure that all code required clearances are maintained.

PART 2 – PRODUCTS

2.1 GENERAL:
A. Provide over current protective devices and ancillary components of types, sizes, ratings, and electrical characteristics indicated. Provide enclosures in NEMA ratings as indicated and suitable for applications.

2.2 MOLDED CASE CIRCUIT BREAKERS:
A. MANUFACTURERS: Subject to compliance with all requirements, provide molded case circuit
breakers from one of the following:

1. General Electric
2. Siemens
3. Square D

B. MOLDED CASE CIRCUIT BREAKERS:

1. Provide factory-assembled, molded case circuit breakers as integral components of lighting and appliance panel boards, power panel boards, switchboards, and for individual mounting as indicated. Provide thermal magnetic, molded case circuit breakers of amperages, voltages, types, and short circuit current ratings indicated. Provide bolt-on type breakers only. Construct with quick-break, quick-break mechanism with inverse-time delay and instantaneous trip protection for each pole. Provide breakers rated for ambient temperatures to suit respective applications. Provide mechanical screw type removable copper connector lugs of size to accommodate conductors specified.
2. Provide breakers that have interrupting ratings greater than or equal to the specified fault current. Provide fully-rated systems only. Series-rated systems are not acceptable, unless specifically noted otherwise.

2.3 ELECTRONIC CIRCUIT BREAKERS:

A. VENDORS: Subject to compliance with all requirements, provide electronic circuit breakers from one of the following:

1. Eaton Cutler-Hammer
2. General Electric
3. Siemens
4. Square D

B. ELECTRONIC CIRCUIT BREAKERS:

1. Provide factory-assembled, electric circuit breakers as integral components of power panel boards and switchboards. Unless noted otherwise on drawings, provide electronic circuit breakers in accordance with requirements as set forth in “MOLDED CASE CIRCUIT BREAKERS” above and with features as follows:
2. Provide electronic circuit breakers having the following selectable settings:
   a. Long time pickup and delay.
   b. Short time pickup and delay with I2T In and I2T Out features.
   c. Instantaneous.
   d. Ground fault pickup and delay with I2T In and I2T Out features.
3. Provide electronic circuit breakers having the following additional features:
   a. 80% rated.
   b. True RMS sensing.
   c. Interchangeable rating plugs.
   d. Thermal and magnetic backup protection.
   e. Long time and ground fault memory.
4. For any circuit breaker that is rated or can be adjusted to 1,200 amps or higher, provide an arc energy reduction maintenance switch that will allow the instantaneous trip setting to be adjusted less than the available arcing current. The switch shall be provided with settings that will allow for at least five (5) levels of reduction.

2.4 FUSES:

A. VENDORS: Subject to compliance with all requirements, provide fuses from one of the
following:

1. Bussmann
2. Gould Shawmut
3. Reliance
4. Littlefuse

B. FUSES: Provide fuses as integral components of disconnects, fusible switches, and bolted pressure switches. Provide fuses in types and sizes as recommended by manufacturer’s written instructions. Provide fuses for mains, feeders, and branch circuits as follows:

1. Circuits 601 to 6000 amperes: Shall be protected by current limiting Bussmann Low-Peak Time-Delay Fuses KRP-C or equivalent. Fuses shall be UL Class L with an interrupting rating of 200,000 amperes r.m.s. symmetrical.
2. Motor and Transformer Circuits 0 to 600 amperes: Shall be protected by current-limiting Bussmann Low-Peak Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts) or equivalent. Fuses shall be UL Class RK1 with an interrupting rating of 200,000 amperes r.m.s. symmetrical.
3. Feeders to Circuit Breaker Panels 0 to 600 amperes: Shall be protected by current-limiting Bussmann Low-Peak Time Delay fuses LPJ or equivalent. Fuses shall be UL Class RK1 with an interrupting rating of 200,000 amperes r.m.s. symmetrical.

C. FUSE CABINETS:

1. Furnish and install fuse cabinet(s) equivalent to Bussmann SFC-FUSE-CAB.

PART 3 – EXECUTION

3.1 GENERAL:

A. Install overcurrent protective devices in accordance with manufacturer’s written instructions, applicable requirements of NEC, NEMA standards, and NECA’s “Standards of Installation”, and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 SIZING FUSES:

A. Size all fuses in accordance with manufacturer’s written recommendations, whether fuse size is indicated on drawings or not. If nuisance tripping occurs, increase fuse size and disconnect if necessary as required to provide nuisance-free tripping. Adjust fuse size for proper ambient temperature, frequent starting and stopping of motor loads, and for loads with long start times.

3.3 IDENTIFICATION:

A. Provide 1/16” thick black plastic laminate labels with 1/4” high lettering on the exterior of each disconnect indicating name of disconnect or load served. Bolt labels to enclosure. Mark on interior cover the source of power by indicating the panel and circuit number.

B. Provide red plastic laminate label for disconnects supplied by emergency power.

3.4 MOUNTING:

A. Mount disconnects as indicated, but in no case higher than 6’-6” from finished floor to top of disconnect. Anchor enclosures firmly to walls and structural surfaces.
B. Provide 4" high concrete pad under floor-standing disconnects.

3.5 SETTINGS:

A. Adjust settings of overcurrent protective devices as directed by engineer.

3.6 TESTING OF GROUND FAULT PROTECTION:

A. Have all ground fault protection systems tested by authorized factory representative for proper operation. Replace all malfunctioning units. A complete record of current trip level and time required to trip the disconnecting device shall be submitted to the owner.

3.7 SPARE PARTS:

A. Spare Fuses: For each type and ampere rating, furnish one spare fuse for every 5 provided, but not less than three total.

B. Fuse Cabinets: Furnish and install fuse cabinet(s) in quantities as required, but in no case less than one, to house the spare fuses indicated above. Locate in main electrical room as directed by the Electrical Engineer.

END OF SECTION 26 0180
SECTION 26 0182
SWITCHBOARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to switchboards.

1.2 DESCRIPTION OF WORK:
A. Extent of switchboards is indicated by drawings and schedules and is specified herein.

1.3 QUALITY ASSURANCE:
A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.
B. SUBMITTALS:
   1. Shop Drawings: Submit dimensioned drawings of switchboards and enclosures showing accurately scaled layouts of enclosures. Include schedule of devices, including, but not necessarily limited to, circuit breakers, fusible switches, fuses, and accessories.
   2. Equipment Room Layouts: Submit dimensioned drawings of all equipment rooms indicating spatial relationships to other proximate equipment. Insure that all code required clearances are maintained.

PART 2 – PRODUCTS

2.1 VENDORS:
A. Subject to compliance with all requirements, provide products from one of the follows:
   1. Eaton Cutler-Hammer
   2. General Electric
   3. Siemens
   4. Square D

2.2 GENERAL:
A. Provide switchboards, enclosures, and ancillary components, of types, sizes, and ratings indicated. Provide overcurrent protective devices, etc. as indicated on drawings for a complete installation. See Section 26 0180 – Overcurrent Protective Devices.
B. Rate devices, etc. equal to or greater than the short circuit current rating indicated. Provide fully-rated systems only. Series-rated systems are not acceptable, unless specifically noted.
otherwise.

2.3 **AC DEAD-FRONT SWITCHBOARDS:**

A. Provide factory assembled, front accessible, dead-front, floor-standing switchboards in NEMA types to suit respective applications. Construct bus bars of aluminum, braced to withstand RMS symmetrical fault current indicated. Provide ground bus in each section. Provide ANSI-61 painted finish.

B. Lugs shall be CU-AL rated.

**PART 3 – EXECUTION**

3.1 **GENERAL:**

A. Install switchboards in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 **IDENTIFICATION:**

A. Provide 1/16" thick black plastic laminate labels with 1/4" high lettering on exterior of each enclosure indicating name of switchboard. Bolt labels to enclosure. Mark on enclosure the source of power by indicating the panel and circuit number.

3.3 **MOUNTING:**

A. Provide 4" high concrete pad. Mount switchboard as indicated, but in no case higher than 6'-6" from finished floor to top of switchboard including concrete pad. Bolt switchboard to concrete pad in accordance with Section 26 0072 – Electrical Support and Seismic Restraints.

3.4 **CIRCUIT DIRECTORIES:**

A. Provide 1/16" thick black plastic laminate labels with 1/4" high lettering for each load served.

3.5 **WIRING METHODS:**

A. Arrange conductors neatly within enclosure, and secure with suitable nylon ties.

**END OF SECTION 26 0182**
PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes Type 2 Surge Protective Devices for low-voltage power.

B. Related Sections include the following:
   1. Division 26 Section "Switchboards" for factory-installed SPDs.
   2. Division 26 Section "Panelboards" for factory-installed SPDs.
   3. Division 26 Section "Motor Control Centers" for factory-installed SPDs.

1.3 DEFINITIONS


B. VPR: Voltage Protection Rating.

C. SPD: Surge Protection Device.

1.4 SUBMITTALS

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

B. Product Certificates: For surge protective devices, signed by product manufacturer certifying compliance with the following standards:
   1. UL 1283.
   2. UL 1449 3rd Edition.
   3. UL 281-1 (fuse)
   4. CSA 22.2.
   5. NEMA LS-1

C. Manufacturer Seismic Qualification Certification: Submit certification that surge protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Electrical Supports and Seismic Restraints." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Products Testing: For surge protective devices, provide the following product test data:

1. Provide actual let through voltage test data in the form of oscillograph results for the ANSA/IEEE C62.41 Category C3 & C1 (combination wave) and B3 (ringwave) tested in accordance with ANSI/IEEE C62.45.

2. Provide spectrum analysis of each unit based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying the device noise attenuation equal or exceeds 50 db at 100 kHz.

3. Provide test report in compliance with NEMA LS1 from a recognized independent testing laboratory verifying that surge protection device components can survive published surge current rating on both a per mode and per phase basis using the IEEE C62.41, 8 x 20 microsecond current wave. Note that test data on individual module is not accepted.

E. Field quality-control test reports, including the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

F. Operation and Maintenance Data: For surge protective devices to include in emergency, operation, and maintenance manuals.

G. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


C. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."


E. The manufacturer shall be ISO 9000 certified.

F. Comply with Military Standards MIL-STD220A.

G. Comply with FIPS Pub 94.


1.6 PROJECT CONDITIONS
A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: -40 to 140 deg F.
3. Humidity: 5 to 95 percent, non-condensing.
4. Altitude: Up to 20,000 feet above sea level.

1.7 COORDINATION

A. Coordinate location of field-mounted surge protection devices to allow adequate clearances for maintenance. Coordinate placement of breakers in electrical panelboards feeding field-mounted surge protection devices so that conductor leads are kept to an absolute minimum.

B. Coordinate surge protection devices with Division 26 Section "Electrical Power Monitoring and Control."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge protection devices that fail in materials or workmanship within five years from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

3. EFI Electronics
5. LEA International.
7. Liebert Corporation; a division of Emerson.
9. Square D; Schneider Electric.

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

A. Electrical Requirements:
1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall be greater than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge protection device for the service entrance and other distribution level. The system shall not utilize silicon avalanche diodes, selenium cell, air gaps or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
4. Protection Modes – For a wye-configured system, the device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta-configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).
5. UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum UL 1449 3rd Edition VPR for the device must not exceed the following:
   a. 208Y/120 V:
      1) L-N; L-G; N-G: 700 V.
      2) L-L: 1200 V.
   b. 480Y/277 V:
      1) L-N; L-G; N-G: 1200 V.
      2) L-L: 2000 V.
6. ANSI/IEEE Cat. C3 Let Through Voltage – The let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10 kA) shall be less than:
   a. 208Y/120 V L-N: 560 V.
   b. 480Y/277 V L-N: 960 V.
7. ANSI/IEEE Cat. B3 Let Through Voltage – Let through voltage based on IEEE C62.41 and C62.45 recommended procedures for the ANSI/IEEE Cat. B3 ringwave (6 kV, 500 amps) shall be less than:
   a. 208Y/120 V L-N: 160 V.
   b. 480Y/277 V L-N: 165 V.

B. SPD Design

1. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating SPD modules shall not be acceptable.
2. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHz using the MIL-STD-220A insertion loss test method. Products not able to demonstrate noise attenuation of 50 dB @ 100 kHz shall be rejected.
3. Extended Range Filter – The Surge Protective Device shall have a High Frequency Extended Range Tracking Filter in each Line to Neutral mode with compliance to UL 1283 and NEMA LS1. The filter shall have published high frequency attenuation rating in the attenuation frequencies:
   a. Insertion Loss (ratio):
      1) 50kHz: 40
      2) 100kHz: 316
      3) 500kHz: 316
      4) 1MHz: 89
      5) 10MHz: 200
      6) 100MHz: 79
   b. Insertion Loss (dB):
      1) 50kHz: 32
      2) 100kHz: 50
      3) 500kHz: 50
4) 1MHz: 39
5) 10MHz: 46
6) 100MHz: 38

4. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.

5. Standard Monitoring Diagnostics – Each SPD shall provide integral monitoring options:
   a. Each unit shall provide a green / red solid state indicator light shall be provided on each phase. The absence of a green light and the presence of a red light shall indicate which phase(s) have been damaged.
   b. Contacts for Remote Status Monitoring – The SPD device must include form C dry contacts (one NO and one NC) for remote annunciation of unit status. The remote alarm shall change state if any of the three phases detect a fault condition.

6. Overcurrent Protection Fusing: In order to isolate the SPD under any fault condition, the manufacturer shall provide:
   a. Individual Fusing: MOVs shall be individually fused via Copper Fuse Trace. The Copper Fuse shall allow protection during high surge (kA) events. SPD shall safely reach an end-of-life condition when subjected to fault current levels between 0 and 200 kA, including low level fault currents from 5 to 5000 amperes.
   b. Thermal Protection: MOVs shall be equipped with Thermal Fuse Spring (TFS) technology which allows disconnection of the suppression component at the overheated stage common during temporary over voltage condition. For small fault currents between 100mA to 30Amp, or if the occurrence is over a longer period of time, the TFS will disconnect first. Manufacturers that utilize fuse trace only shall not be approved since there is no fault current protection between 100mA to 30A.
   c. All overcurrent protection components shall be tested in compliance with UL 1449-Limited Current Test and AIC rating test.


1. The suppression filter system shall be repetitive surge tested in every mode utilizing a 1.2 x 50 microseconds, 20kV open circuit voltage. 8 x 20 microsecond, 10kA short circuit current Category C3 bi-wave at one minute intervals without suffering either performance degradation or more than 10% deviation of clamping voltage at a specified surge current. The minimum repetitive surge current capability as per ANSI/IEEE C62.41 and ANSI/IEEE C62.45 – 1992 shall be:
   a. Service Entrance: 5000 impulse per mode.
   b. Distribution Locations: 5000 impulse per mode.
   c. Branch Locations: 5000 impulse per mode.

2.3 SYSTEM APPLICATION

A. Locations – Electrical drawings indicate the location and IEEE Category requirements of all required SPD’s.

B. Surge Current Capacity – The minimum total surge current 8 x 20 microsecond waveform that the device is capable of withstanding shall be as follows:

1. IEEE Category "C" Locations:
   a. Per Phase: 250kA.
   b. Per Mode: 125kA.

2. IEEE Category "B" Locations:
   a. Per Phase: 160kA.
b. Per Mode: 80kA.

3. IEEE Category "A" Locations:
   a. Per Phase: 120kA.
   b. Per Mode: 60kA.

C. Lighting and Appliance Panelboard Requirements:

1. Factory-Installed SPD Option:
   a. The SPD shall not limit the use of Through-feed lugs, Sub-feed lugs and Sub-feed breaker options.
   b. The SPD shall be immediately installed on the load side of the main breaker or main lugs.
   c. The panelboard shall be capable of re-energizing upon removal of the SPD.
   d. A direct bus bar connection shall be used to mount the SPD component to the panelboard bus bar to reduce the impedance of the shunt path.
   e. The SPD panelboard shall be constructed using a direct bus bar connection (cable connection between bus bar and SPD device in not acceptable). SPD units that use a cable connection do not meet the intent of this specification. For this option, the breaker shown on the electrical drawings shall be deleted.
   f. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
   g. The SPD shall be of the same manufacturer as the panelboard.
   h. The complete panelboard including the SPD shall be UL67 listed.

D. Power Distribution Panelboard and Switchboard Requirements:

1. Factory-Installed SPD Option:
   a. The SPD shall be of the same manufacturer as the power distribution panelboard, motor control center, or switchboard.
   b. The SPD shall be factory installed inside the power distribution panelboard, motor control center, or switchboard at the assembly point by the original equipment manufacturer.
   c. Locate surge protection device on load side of main disconnect device or main lugs, as close as possible to the phase conductors and ground/neutral bar.
   d. Provide a disconnect sized in accordance with all manufacturer’s recommendations. The disconnect shall be directly integrated to the surge protection device and assembly bus by using bolted bus bar connections. The disconnect is the preferred method. If otherwise recommended by the manufacturer, provide a multi-pole circuit breaker in the panelboard in size as recommended by the manufacturer to feed the surge protection device. The size of the breaker shall supersede the size of the breaker shown on the electrical drawings. Provide copper conductors in size as recommended by the manufacturer for connecting the phases, neutral, and ground between the surge protection device and the circuit breaker in the panelboard. The size of the conductor shall supersede the size of the conductors shown on the electrical drawings.
   e. The SPD shall be integral to power distribution panelboard, motor control center, or switchboard as factory standardized design.
   f. All monitoring diagnostics features shall be visible from the front of the equipment.

2.4 ENCLOSURES

A. Provide enclosures suitable for locations as indicated on the drawings or as described below:

1. NEMA 12 dust-tight enclosures intended for indoor use primarily to provide protection
against circulating dust, falling dirt and dripping non-corrosive liquids. (Panelboards
Only)

PART 3 – EXECUTION

3.1 INSTALLATION OF SURGE PROTECTION DEVICES
A. Install devices at service entrance on load side, with ground lead bonded to service entrance
ground.
B. Install devices for panelboard and auxiliary panels with conductors or buses between surge
protection device and points of attachment as short and straight as possible. Do not exceed
manufacturer's recommended lead length. Do not bond neutral and ground at SPD.

3.2 PLACING SYSTEM INTO SERVICE
A. Do not energize or connect electrical equipment to their sources until surge protection devices
are installed and connected.

3.3 FIELD QUALITY CONTROL
A. Testing: Perform the following field tests and inspections and prepare test reports:
   1. After installing surge protection devices, but before electrical circuitry has been
      energized, test for compliance with requirements.
   2. Complete startup checks according to manufacturer's written instructions.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS,
      "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance
      with test parameters.
B. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to
   adjust, operate, and maintain surge protective devices. Refer to Division 1 Section "Closeout
   Procedures" or "Demonstration and Training" as may be applicable.

END OF SECTION 26 0289
SECTION 26 0420
SERVICE ENTRANCE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to service entrances.

1.2 DESCRIPTION OF WORK:
A. Extent of service entrance work is indicated by drawings and schedules and is specified herein.
B. Work under this section includes the following:
   1. Power Company Coordination and Fees
   2. Power Company Transformer Pads
   3. Raceways and Conductors
   4. CT Enclosures
   5. Metering
   6. Service Entrance Switchboards and/or Panelboards
   7. Overcurrent Protective Devices and/or disconnects

1.3 QUALITY ASSURANCE:
A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.
B. SUBMITTALS:
   1. Shop Drawings: Submit manufacturer's data on service entrance equipment and accessories. Submit dimensioned drawings of service entrance equipment.
   2. Equipment Room Layouts: Submit dimensioned drawings of all equipment rooms containing service entrance equipment indicating spatial relationships to other proximate equipment. Insure that all code required clearances are maintained.

PART 2 – PRODUCTS

2.1 GENERAL:
A. Provide service entrance equipment and accessories of types, sizes, ratings, and electrical characteristics indicated or as otherwise required to provide a complete system. See other applicable sections.

2.2 POWER COMPANY COORDINATION AND FEES:
A. Coordinate and comply with all power company requirements. Confirm location of point of service before bidding. Logan City School District will pay all associated power company fees.

2.3 POWER COMPANY TRANSFORMER PADS AND VAULTS:
A. Provide steel reinforced, concrete transformer pads and/or vaults of sizes and with openings in accordance with the latest standards and requirements of the local power company. Verify all requirements with Power Company prior to installation.

2.4 RACEWAYS AND CONDUCTORS:
A. Provide service entrance raceways and conductors in accordance with Section 26 0110 – Conduit Raceways, and Section 26 0120 – Conductors and Cables.

2.5 CT ENCLOSURES:
A. Provide CT enclosures complete with meter bases of types and sizes in accordance with all power company requirements. Provide steel reinforced, concrete pads with openings in accordance with same. Refer to "Concrete Bases" under Section 26 0001 – Electrical General Provisions. Verify and comply with all power company requirements prior to installation.

2.6 METERING:
A. Meter Bases: Provide meter bases in accordance with all power company requirements. Extend 1” empty conduit from meter bases to secondary compartment of power company transformer. Verify exact location of meter bases prior to installations.

1. Meters:
   a. Subject to compliance with all requirements, provide metering equipment from one of the following:
      1) General Electric
      2) Siemens
      3) Square D
      4) Cutler Hammer

2.7 SERVICE ENTRANCE SWITCHBOARDS AND/OR PANELBOARDS:
A. Provide service entrance switchboards and/or panelboards in accordance with Section 26 0182 – Switchboards, and Section 26 0160 – Panelboards. Rate all service switchboards and/or panelboards as service entrance equipment.

2.8 OVERCURRENT PROTECTIVE DEVICES AND/OR DISCONNECTS:
A. Provide overcurrent protective devices and/or disconnects in service switchboards and/or panelboards in accordance with Section 26 0180 – Overcurrent Protective Devices, and Section 26 0170 – Disconnect Switches.

PART 3 – EXECUTION

3.1 GENERAL:
A. Install service entrance equipment and accessories in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of
Installation“, and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 TRANSFORMER LOCATIONS:

A. Verify and coordinate exact placement of concrete pad with local power company prior to installation. Strictly maintain sufficient distances from door, window, building walls and overhangs, gas meters, fuel tanks, etc. in accordance with all power company requirements. Field-verify placement of transformer pad in company with the local power company representative.

3.3 COORDINATION:

A. Coordinate all service entrance work with other trades.

B. Power Company Coordination: Coordinate installation of service entrance equipment with Power Company and insure that power to building is ready when needed. After the contract has been signed, immediately notify the engineer that the project is underway and indicated when power to the building/project is needed. It is the engineer's responsibility to complete and submit the power company service request form.

END OF SECTION 26 0420
SECTION 26 0435
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.

1.4 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data, where required, shall be provided on CD in PDF format.

B. For large system studies with more than 200 bus locations, the contractor is required to provide the study project files to the owner in electronic format. In addition, a copy of the computer analysis software viewer program is required to accompany the electronic project files, to allow the owner to review all aspects of the project and print arc flash labels, one-line diagrams, and other items.

C. The report shall include the following sections:
1. Executive summary
2. Descriptions, purpose, basis, and scope of the study
3. Tabulations of circuit breaker, fuse, and other protective device rating versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations, including a definition of terms and guide for interpretation of the computer printout
6. Details of the incident energy and flash protection boundary calculations
7. Recommendations for system improvements, where needed
8. One-line diagram

D. Arc flash labels shall be provided in hard copy only.

1.5 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

   1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. The equipment manufacturer or approved engineering firm shall demonstrate experience with arc flash hazard analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.

D. The contractor shall furnish an arc flash hazard analysis study, per the requirements set forth in NFPA 70E – Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

F. Comply with IEEE 399 for general study procedures.


PART 2 – PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

   1. CGI CYME.
   2. EDSA Micro Corporation.
2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:
   a. Arcing faults.
   b. Simultaneous faults.
   c. Explicit negative sequence.
   d. Mutual coupling in zero sequence.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
   a. Circuit-breaker and fuse-current ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   d. Generator kilovolt amperes, size, voltage, and source impedance.
   e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
f. Busway ampacity and impedance.
g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company’s overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated.
   h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
   1. Switchgear and switchboard bus.
   2. Medium-voltage controller.
   3. Motor-control center.
   4. Distribution panelboard.
   5. Branch circuit panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers:
   a. ANSI C57.12.10.
   b. ANSI C57.12.22.
   c. ANSI C57.12.40.
   d. IEEE C57.12.00.
   e. IEEE C57.96.

4. Low-Voltage Fuses: IEEE C37.46.
E. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:
1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY


1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

H. Set ground fault protective equipment such that coordination with 277V, 20A-1P branch breakers are coordinated to the greatest extent possible.

3.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. The arc flash hazard analysis shall include all significant locations to 240 volt and 209 volt systems fed from transformers equal to, or greater than, 125 kVA, where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary, considering an incident energy of 1.2 cal/cm2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum mother contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into considering the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when
performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows.

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker, as required above, the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to computer the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds, based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

3.6 ARC FLASH WARNING LABELS

A. The contractor of the arc flash hazard analysis shall provide a 3.5 inch x 5 inch thermal transfer-type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device setting and will be provided after the results of the analysis have been presented to the owner, and after any system changes, upgrades, or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category
5. Incident energy
6. Working distance
7. Engineering report number, revision number, and issue date

D. Labels shall be machine-printing, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600, 480, and applicable 208 volt panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low-voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, on flash label shall be provided.
5. For medium voltage switches, one arc flash label shall be provided.

F. Labels shall be field-installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.7 ARC FLASH TRAINING

A. The contractor of the arc flash hazard analysis shall train the owner’s qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET), or equivalent.

END OF SECTION 26 0435
SECTION 26 0452
GROUNDING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.
B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to grounding.

1.2 DESCRIPTION OF WORK:
A. Extent of grounding work is indicated by drawings and schedules and is specified herein.
B. Ground the complete electrical installation including the system neutral, metallic conduits and raceways, boxes, fittings, devices, cabinets, equipment, and separately derived systems in accordance with the NEC and all other applicable codes to provide a permanent, continuous, low impedance, grounding system.
C. Provide grounding system such that the resistance from the service entrance ground bus, through the grounding electrode to earth is not greater than 5 ohms.

1.3 QUALITY ASSURANCE:
A. STANDARDS: Refer to Section 26 0001 – Electrical General Provisions as applicable.
B. TESTING: Submit results of ground resistance testing as specified in this section. Include name of testing agency with report. Include test results in operation and maintenance manuals.

PART 2 – PRODUCTS

2.1 GENERAL:
A. Provide grounding equipment and accessories of types, sizes, ratings, and electrical characteristics indicated or as otherwise required to provide a complete system.

2.2 GROUNDING CONDUCTORS:
A. Unless noted otherwise, provide grounding conductors with stranding and insulation types to match phase conductors. Provide conductors with green insulation if possible; otherwise wrap with green tape. Size ground conductors as indicated on drawings. Do not size ground conductors smaller than that allowable by NEC.

2.3 GROUND RODS:
A. Provide copper clad, steel, 3/4" diameter by 10' long, ground rods (Weaver, Cadweld, or
2.4 **TEST WELLS:**

A. Provide precast concrete box 9-1/2" W. x 16" L. x 18" D. with light duty concrete cover for non-traffic areas or rated steel plate for traffic areas. Provide covers with lifting holes. Engrave cover with "Ground Rod".

2.5 **CONCRETE ENCASED GROUNDING ELECTRODE (UFER GROUND):**

A. Provide a bare copper conductor encased along the bottom of concrete foundation or footing that is in direct contact with the earth and where there is no impervious water-proofing membrane between the footing and the soil. Size UFER ground conductor in accordance with the NEC. Extend conductor through a horizontal length of 30' minimum and encase with not less than 2 nor more than 5 inches of concrete separating it from surrounding soils.

2.6 **INSULATED GROUNDING BUSHINGS:**

A. Provide plated malleable iron body with 150 degree Centigrade molded plastic insulating throat, lay-in grounding lug with hardened stainless steel fasteners (OZ Gedney BLG or equivalent).

2.7 **CONNECTION TO PIPES:**

A. Provide heavy duty, cast bronze, ground clamp systems with silicon bronze bolts and nuts (OZ Gedney G Series - B or equivalent).

2.8 **CONNECTIONS TO STRUCTURAL STEEL, GROUND RODS, OR SPLICES:**

A. Provide exothermic welds. (Cadweld or equivalent)

2.9 **BONDING JUMPERS:**

A. Provide bonding jumpers with hot dip galvanized malleable or ductile iron clamps, hot dip galvanized steel U-bolts, and tinned copper braids (OZ Gedney BJ Series or equivalent).

2.10 **GROUND BUS:**

A. Provide 1/4" x 4", copper ground bus complete with insulators and brackets in lengths and at mounting heights as indicated on drawings. Furnish complete with drilled holes and lugs to accommodate grounding conductors.

**PART 3 – EXECUTION**

3.1 **GENERAL:**

A. Install grounding systems in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 **CLEANING:**

A. Thoroughly clean all metal contact surfaces prior to installation of clamp-on connectors.
3.3 SEPARATELY DERIVED SYSTEMS:

A. Ground each separately derived system in accordance with NEC Section 250-16 unless otherwise indicated on drawings.

3.4 SERVICE ENTRANCE GROUNDING:

A. Connect the following items using NEC sized copper grounding electrode conductors (in NEC sized, conduits if concealment is required) to lugs on the service ground bus:

1. Conductor from the UFER ground.
2. Conductor from two ground rods driven exterior to building at not less than 10’ apart.
3. Conductor from main incoming cold water piping system.
5. Conductor from separately derived systems.
6. Conductor from insulated ground bushings on service entrance conduits.
7. Additional ground rods as required to achieve resistance value specified.
8. Additional items indicated on drawings.

3.5 EQUIPMENT BONDING AND GROUNDING:

A. Provide an NEC sized copper conductor, whether indicated or not on the drawings, in raceways as follows:

1. Non-metallic conduits and ducts.
2. Distribution feeders.
3. Motor and equipment branch circuits.
4. Device and lighting branch circuits.
5. Full length of all multi-outlet assemblies and other surface wireways.

3.6 ADDITIONAL GROUNDING INSTALLATION REQUIREMENTS:

A. Provide grounding bushings on all service conduit and conduits installed in concentric/eccentric knock-outs or reducing washer at panelboards, cabinets, and gutters.

B. Provide bonding jumpers across expansion and deflection couplings in conduit runs, across pipe connections at water meters, and across dielectric couplings in metallic cold water piping system. Connection to water piping system shall be made electrically continuous by connecting to the street side of the water main valve and/or installing additional bonding jumpers across the meter, valves or service unions that might be disconnected.

C. Provide bonding wire in all flexible conduits.

D. Isolated Ground Circuits: Circuits used for isolated ground outlets shall be run in separate raceways or shall have a separate green insulated ground conductor installed and tagged for identification at all outlet and junction boxes.

3.7 TEST WELLS:

A. All ground rods shall be driven external to building and shall be located in ground well boxes. Locate in landscaped areas where possible.

3.8 TESTING:

A. Obtain and record ground resistance measurements both from service entrance ground bus to
the ground electrode and from the ground electrode to earth. Install additional bonding and grounding electrodes as required to comply with resistance limits specified under this Section. Use independent testing agency for all testing.

END OF SECTION 26 0452
SECTION 26 0523
UTILITY HORIZONTAL DIRECTIONAL DRILLING

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Contractor shall provide all work, material, labor, equipment, and supervision necessary to
      complete the directional drilling and other work, as required within the project documents.
   B. The specification includes HDPE installation by means of horizontal directional drilling for the
      intended use as a raceway system for telecommunications cabling.
   C. Contractor shall be responsible to research and obtain all necessary permits, easements, right
      of ways, and written authorizations to complete the required work.

1.3 DEFINITIONS
   A. HDD: Horizontal Directional Drilling.
   B. HDPE: High Density Polyethylene Conduit.
   C. A/E: Architect/Engineer

1.4 SUBMITTALS
   A. Not Required.

1.5 CLOSEOUT SUBMITTALS
   A. Copy of site condition video before HDD work begins and after HDD work is completed and
      landscaping and surfaces have been completely repaired.
   B. As-built contractor red-lines.
   C. Tracer wire continuity test report summary.
1.6 QUALITY ASSURANCE

A. HDD work shall be performed by a qualified HDD company with at minimum of 3 years of HDD experience with work of similar scope. Company must have experience with quad duct boring conduits between 1”-4” in diameter.

B. All applicable permits, applications, and approvals must be in place prior to beginning work.

PART 2 - PRODUCTS

2.1 HDPE Conduit

A. Conduit shall comply with ASTM F 2160 and shall meet or exceed the properties listed in ASTM D-3350 for minimum cell classification.

B. Conduit shall be suitable for use as a direct buried underground raceway system and constructed from high density polyethylene.

C. Raceway shall be continuous and fully sealed from water and debris from pull location to pull location.

D. Raceway to include legible, permanent markings a minimum of every 5 feet along the conduit length which include: HDPE designation, trade size, type, thickness, schedule, sequential foot markings.

E. Fitting shall be socked fused or butt fused and shall be approved and provided by the HDPE conduit manufacturer.

2.2 PULLING TAPE

A. Pulling tape shall be flat, woven style polyester with available with printed sequential markings in feet, minimum 200 lb pulling strength. The product version used shall be selected with the manufacturer’s recommendations for the specific project installation, or as called out on the drawings.

1. Approved Manufacturers:
   a. Neptco “Muletape”

2.3 MISCELLANEOUS PRODUCTS

A. Tracer Wire shall be insulated #10 gauge hard drawn copper clad steel core locating wire.

B. Drilling Fluid shall be ANSI/NSF 60 certified, bentonite-based drilling fluid. Temperature test below is optional; revise to suit Project. If Project includes more than one transformer of a given kilovolt-ampere rating, consider testing one unit only.
PART 3 - EXECUTION

3.1 PREPARATION

A. Obtain all required permits, easements, right-of-ways, and permissions for work prior to beginning.

B. Survey the entire drill path with entry and exit locations identified and marked. Locate and identify all subsurface utilities that are to be crossed as well as any subsurface utilities along the path which may pose a conflict to the bore and entry/exit locations.

C. Blue-stake the project site to ensure all known subsurface utilities are identified.

D. Potholing
   1. Positively identify location and depth of all subsurface utility crossings prior to boring.
   2. Locate other subsurface utilities along the path of the bore and near entry and exit locations prior to boring.
   3. Location of subsurface utilities shall utilize one of the following methods: vacuum-excavation hydro-excavation, or hand excavation.

3.2 EXCAVATION

A. Required directional drilling pits and pullbox locations shall be excavated and maintained to minimum dimensions. Excavations shall be adequately barricaded, sheeted, braced, and dewatered.

B. Excavation adjacent to the road or pavement/concrete surface shall be performed in a manner to adequately support these facilities.

3.3 DIRECTIONAL DRILLING OPERATION

A. Conduit shall be handled, stored and joined in accordance with manufacturer's instructions.

B. Pre-excavate pipe entry and receiving areas to provide a gradual entry of the conduit and to reduce stress on the conduit. Guide drilling to avoid deformation of or damage to the conduit. Deformation or damage to the conduit shall require removal of the damaged conduit and re-installation of non-damage conduit.

C. Bore and install the quantity and size of conduits as indicated on the drawings.

D. If unexpected subsurface conditions are encountered during the bore, the procedure shall be stopped. The boring shall not continue until approval has been provided by the A/E.

E. The Drilling mud shall be contained and disposed of in accordance with state/federal regulations and permit conditions.

F. The Contractor shall install erosion and sedimentation control measures including, but not limited to straw bales to prevent drilling mud from spilling out of entrance/exit pits and pressure relief vents.
G. Every effort shall be made to maintain the conduit installation to a consistent depth within the requirements noted on the drawings, but in no case less than 24” below grade.

H. The Contractor shall make adjustments to the routing and depth of the conduit installation without additional cost to the Owner in order to route around utilities, avoid obstructions, or to maintain minimum clearances from other buried utilities. The minimum separation from other utilities shall be 36” for parallel utilities and 24” for crossings of utilities.

I. The HDD and conduit installation shall not cause upheaval, settlement, cracking, movement or distortion of surface features. The contractor shall be responsible at no additional cost to the Owner to sawcut and repair any damaged surfaces or features to match existing conditions.

J. The system must be remotely steerable with location and depth continuously monitored. The system must be able to control depth and direction with a 2” tolerance in each direction.

K. Install tracer/locating wire within each conduit for the entire length of the conduit run. A continuity test shall be performed by the Contractor for all tracer wires, continuity test result report shall be submitted with O&M’s for each tracer wire.

L. Annular space between the conduit and bore hole shall be filled with a Bentonite or equal material to support and stabilize the installation.

M. In the case of a pull-back where the bore will be abandoned, the Contractor shall inject an approved grout into the annular space. The injection shall be in conjunction with the removal of the bore tool to insure against collapse of the cover material.

3.4 DOCUMENTATION

A. Contractor shall video tape the site conditions along the entire bore path and excavation sites to document the conditions of the project site prior to beginning any work. This video tape shall be submitted on DVD digital media in a standard video format as part to the Operation and Maintenance submittal upon completion of the project.

B. Contractor shall video tape the site conditions along the entire bore path and excavation sites to document the conditions of the project site after all work and site repair is complete. This video tape shall be submitted on DVD digital media in a standard video format as part to the Operation and Maintenance submittal upon completion of the project.

C. The contractor shall accurately red-line the as-built location of the entire length of the bore to a tolerance of 6” in either direction. As-build contractor red-lines with elevations and dimensions from landmarks shall be submitted upon completion of the project.

1. Readings shall be taken every 20’ and manually noted on the project as-built red-lines

END OF SECTION 26 0523
SECTION 26 0536
CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Wire-basket cable trays.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and other applicable information shown on the structural drawings.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 WIRE-BASKET CABLE TRAYS

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

2. **Cablofil/Legrande.**
3. **Chalfant Manufacturing Company.**
4. **Cooper B-Line, Inc.**
5. **Enduro Systems, Inc.**
6. **Mono-Systems, Inc.**
7. **MP Husky.**
8. **Niedax-Kleinhuis USA, Inc.**
9. **Snaketray.**
10. **Wiremaid Products Division; Vutec Corporation.**

B. **Description:**

1. Configuration: Wires are formed into a standard **2-by-4-inch (50-by-100-mm)** wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
4. Sizes:
   a. Straight sections shall be furnished in standard **118-inch (3000-mm)** lengths.
   b. Wire-Basket Depth: **6-inch (150-mm)** usable loading depth by **12 inches (300 mm)** wide and **18 inches (450 mm)** wide as indicated on the electrical drawings.
5. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.
6. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
7. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.

**2.4 CABLE TRAY ACCESSORIES**

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

**2.5 WARNING SIGNS**

A. Lettering: **1-1/2-inch (40-mm) high**, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

**2.6 SOURCE QUALITY CONTROL**

A. Testing: Test and inspect cable trays according to NEMA VE 1.
PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

F. Fasten cable tray supports to building structure and install seismic restraints.

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 260072 "Electrical Supports and Seismic Restraints."

H. Place supports at 5'-0" (1542-mm-) on centers for a loading capacity of at least 100 lbs (180 kg) per foot.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Do not install more than one cable tray splice between supports.

L. Support wire-basket cable trays with trapeze hangers.

M. Support trapeze hangers for wire-basket trays with 3/8-inch- (10-mm-) diameter rods.

N. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

O. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.

P. Make changes in direction and elevation using manufacturer’s recommended fittings.

Q. Make cable tray connections using manufacturer’s recommended fittings.

R. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
S. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

T. Install cable trays with enough workspace to permit access for installing cables.

U. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

E. Install only low voltage cable in cable trays that are specified under Division 26 Sections, with the exception that fire alarm cables shall not be routed in cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number and size of cables in cable trays do not exceed that permitted by NFPA 70.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 26 0536
SECTION 26 0560
NETWORK LIGHTING CONTROL SYSTEM

PART 1 – GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this Section.

1.2. SUMMARY

A. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.
B. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed)
C. System devices indicated shall be networked together enabling digital communication and shall be individually addressable.
D. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost.
E. The system architecture shall facilitate remote operation via a computer connection.
F. The system shall not require any centrally hardwired switching equipment.
G. The system shall be capable of wireless, wired, or hybrid wireless/wired architectures.

1.3. DEFINITIONS

A. NA

1.4. SUBMITTALS

A. Product Datasheets (general device descriptions, dimensions, wiring details, nomenclature)
B. Riser Diagrams – typical per room type (detailed drawings showing device interconnectivity of devices)
C. Other Diagrams – as needed for special operation or interaction with other system(s)
D. Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up
E. Hardware and Software Operation Manuals
F. Other operational descriptions as needed

1.5. QUALITY ASSURANCE

A. All steps in sensor manufacturing process shall occur in the USA; including population of all electronic components on circuit boards, soldering, programming, wiring, and housing.
B. All components and the manufacturing facility where product was manufactured must be ROHS compliant.
C. In high humidity or cold environments, the sensors shall be conformably coated and rated for condensing humidity and -40 degree Fahrenheit (and Celsius) operation.
D. All applicable products must be UL / CUL Listed or other acceptable national testing organization.

1.6. COORDINATION
A. Coordinate lighting control components to form an integrated interconnection of compatible components.
B. Coordinate lighting controls with BAS (if necessary) either through IP based intercommunication of system or hardwired auxiliary relay outputs.
C. The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.

1.7. **WARRANTY**
   A. All devices in lighting control system shall have a 5 year warranty.

1.8. **SPARE PARTS**
   A. Provide a minimum of 5%, but not less than three (3) of each type of devices as follows:
      1. Low voltage lighting control wall switches – each type utilized.
      2. Daylight sensors.
      3. Occupancy sensors.
      4. Power (relay) packs.
      5. Auxiliary input/output (I/O) Devices.

**PART 2 – PRODUCTS**

2.1. **MANUFACTURERS**
   A. Basis of Design: This specification is based on the nLight® Network Control System from Sensor Switch, an Acuity Brands Company (800-727-7483, [www.sensorswitch.com](http://www.sensorswitch.com)).
   B. Subject to compliance with all requirements, Digital Lighting Management System from Wattstopper, a LeGrande Company (408-988-5331, [www.wattstopper.com](http://www.wattstopper.com)) is also acceptable.
   C. Subject to compliance with all requirements, Lutron Quantum Total Light Management (wired) from Lutron (1.800.523.9466, [www.lutron.com](http://www.lutron.com)) is also acceptable

2.2. **SYSTEM REQUIREMENTS**
   A. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.
   B. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.
   C. System must interface directly with intelligent LED luminaires such that only CAT-5 cabling is required to interconnect luminaires with control components such as sensors and switches (see *Networked LED Luminaire* section)
   D. Intelligent lighting control devices shall communicate digitally, require <4 mA of current to function (Graphic wall stations excluded), and posses RJ-45 style connectors.
   E. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.
   F. Devices within a lighting control zone shall be connected with CAT-5e low voltage cabling in any order.
G. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

H. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

I. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone. Standalone "bus power supplies" shall not be required in all cases.

J. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

K. System shall have one or more primary wall mounted network control "gateway" devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.

L. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.

M. System shall be capable of wirelessly connecting a lighting zone to a WiFi (802.11n) wireless data network for purposes of eliminating the “bridge” devices and all cabling that connects zones to bridge devices.

N. WiFi enabled devices shall be able to detect when WiFi network is down and revert to a user directed default state.

O. WiFi-enabled devices shall be capable of current monitoring

P. WiFi-enabled devices shall utilize WPA2 AES encryption

Q. WiFi-enabled devices shall be able to connect to 802.11b/g/n WiFi networks

R. WiFi-enabled devices shall have at least one local RJ-45 port for communicating with nonWiFi-enabled system devices

S. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.

T. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

U. Devices located in different lighting zones shall be able to communicate occupancy, photocell, and switch information via either the wired or WiFi backbone.

V. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time schedule so as to enable customized time-of-day, day-of-week utilization of a space. Note operating modes should be utilized only in manners consistent with local energy codes.

   a. Auto-On / Auto-Off (via occupancy sensors)
      • Zones with occupancy sensors automatically turn lights on when occupant is detected.
      • Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
• Pressing a switch will turn lights off. The lights will remain off regardless of occupancy until switch is pressed again, restoring the sensor to Automatic On functionality.
b. Manual-On / Auto-Off (also called Semi-Automatic)
• Pushing a switch will turn lights on.
• Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
c. Manual-On to Auto-On/Auto-Off
• Pushing a switch will turn lights on.
• After initial lights on, zones with occupancy and/or photocell sensors turn lights on/off according to occupancy/vacancy and/or daylight conditions.
• Sequence can be reset via scheduled (ex. daily each morning) events
d. Auto-to-Override On
• Zones with occupancy sensors automatically turn lights on when occupant is detected.
• Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
• Sequence can be reset via scheduled (ex. daily each morning) events
e. Manual-to-Override On
• Pushing a switch will turn lights on.
• Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
• Sequence can be reset via scheduled (ex. daily each morning) events
f. Auto On / Predictive Off
• Zones with occupancy sensors automatically turn lights on when occupant is detected.
• Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
• If switch is pressed, lights turn off and a short “exit timer” begins. After timer expires, sensor scans the room to detect whether occupant is still present. If no occupancy is detected, zone returns to auto-on. If occupancy is detected, lights must be turned on via the switch.
g. Multi-Level Operation (multiple lighting levels per manual button press)
• Operating mode designed specifically for bi-level applications
• Enables the user to cycle through the up to four potential on/off lighting states using only a single button.
• Eliminates user confusion as to which of two buttons controls which load
• Three different transition sequences are available in order to comply with energy codes or user preference)
• Mode available as a setting on all nLight devices that have single manual on/off switch (ex. nWSX, nPODM, nPODM-DX).
• Depending on the sequence selected, every button push steps through relays states according to below table
• In addition to achieving bi-level lighting control by switching loads with relays, the ability to command dimming outputs to “step” in a sequence that achieves bi-level operation is present.
W. A taskbar style desktop application shall be available for personal lighting control.

X. An application that runs on "smart" handheld devices (such as an Apple® IPhone®) shall be available for personal lighting control.

Y. Control software shall enable logging of system performance data and presenting useful information in a web-based graphical format and downloadable to .CSV files.

Z. Control software shall enable integration with a BMS via BACnet IP.

AA. System shall provide the option of having pre-terminated plenum rated CAT-5 cabling supplied with hardware.

2.3. INDIVIDUAL DEVICE SPECIFICATIONS

A. Control Module (Gateway)
   a. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet.
   b. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.
   c. Control device shall have three RJ-45 ports for connection to other backbone devices (bridges) or directly to lighting control devices.
   d. Device shall automatically detect all devices downstream of it.
   e. Device shall have a standard and astronomical internal time clock.
   f. Device shall have one RJ-45 10/100 BaseT Ethernet connection.
   g. Device shall have a USB port
   h. Each control gateway device shall be capable of linking 1500 devices to the management software.
   i. Device shall be capable of using a dedicated or DHCP assigned IP address.
   j. Network Control Gateway device shall be the following Sensor Switch model Series: nGWY2

B. Networked System Occupancy Sensors
   a. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
   b. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
   c. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.

(*step only present for devices without separate off button)
d. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.

e. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.

f. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.

g. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.

h. Sensors shall be available in multiple lens options which are customized for specific applications.

i. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

j. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.

k. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue.

l. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

m. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.

n. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.

o. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.

p. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

q. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

r. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)

s. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.

t. Wall switch sensors shall be the following Sensor Switch model numbers, with device color and optional features as specified:

  - nWSD or nWSX (PIR, 1 Relay)
  - nWSD PDT or nWSX PDT (Dual Tech, 1 Relay)
  - nWSD NL (PIR w/ Night Light, 1 Relay)
  - nWSD PDT NL (Dual Tech w/ Night Light, 1 Relay)
  - nWSX NL LV (PIR w/ Night Light, No Relay)
  - nWSD PDT NL LV (Dual Tech w/ Night Light, No Relay)
nWSD LV or nWSX LV (PIR, No Relay, Raise/Lower Dim Ctrl)
nWSD PDT LV or nWSX PDT LV (Dual Tech w/ Night Light, No Relay, Raise/Lower Dim Ctrl)

u. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.
v. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection
w. Embedded sensors shall have an optional photocell
x. Embedded sensors shall be the following Sensor Switch model number:

nES 7 (PIR, No Relay)
nES 7 ADCX (PIR w/ Photocell, No Relay)
nES PDT 7 (Dual Technology, No Relay)
nES PDT 7 ADCX (Dual Technology w/ Photocell, No Relay)

y. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
z. Fixture mount sensors shall be capable of powering themselves via a line power feed.
aa. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
bb. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
c. Sensors shall be the following Sensor Switch model numbers, with device options as specified:

<table>
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<tr>
<th>Model # Series</th>
<th>Occupancy Poles</th>
<th># of Relays</th>
<th>Lens Type</th>
<th>Detection Technology</th>
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<td>PIR</td>
</tr>
<tr>
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<td>-</td>
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</table>
Note: Recessed mount versions of the above ceiling(fixture) mount versions also shall be available (e.g. nCMR(B) 9 => nRMR 9)

bb. System shall have WiFi enabled fixture mountable sensors available.

c. Embedded sensors shall have an optional photocell and 0-10 VDC dimming output

dd. WiFi enable sensors shall be one of the Sensor Switch model numbers:

- nCMRB 6 WIFI (PIR, w/ Relay)
- nCMRB 10 WIFI (PIR, w/ Relay)
- nCMRB 50 WIFI (PIR, w/ Relay)
- nCMRB 9 WIFI (PIR, w/ Relay)

C. Networked System Daylight (Photocell and or Dimming) Sensors

a. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.

b. Photocell and dimming sensor’s set-point and deadband shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.

c. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).

d. Dimming sensors shall control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of class 2 current (typically 40 or more ballasts).

e. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements. (Note: This function should be performed prior to any dimming of the lamps including the "auto set-point" setting.)
f. Combination units that have all features of on/off photocell and dimming sensors shall also be available.
g. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an “offset” from the primary zone.
h. Line voltage versions of the above described photocell and combination photocell/dimming sensors shall be capable of switching both 120 VAC, 277 VAC, and 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor load. Relays shall be dry contacts.
i. Sensor shall be the following Sensor Switch model numbers, with device options as specified:

   nCM(B) PC (on/off))

   nCM(B) ADC (dimming)

   nCM(B) PC ADC (on/off, 0-10 VDC dimming)

   nCMR(B) PC (on/off, single relay)

   nCMR(B) PC ADC (on/off, 0-10 VDC dimming, single relay)

   Note: Recessed mount versions of the above ceiling(fixture) mount versions also shall be available (e.g. nCMR(B) PC => nRMR PC)

j. Network system shall have dimming photocells that can be embedded into luminaire such that only the lens shows on luminaire face.
k. Embedded sensors shall be the following Sensor Switch model number:

   nES ADCX (Dimming Photocell)

D. Networked System Power (Relay) Packs

   a. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2nd relay, 0-10 VDC dimming output, or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.

   b. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.

   c. All devices shall have two RJ-45 ports.

   d. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.

   e. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

   f. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

   g. Power Packs and Power Supplies shall be available that are WiFi enabled.
h. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all lighting load types.
i. Power (Secondary) Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.
j. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts/LED drivers.
k. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
l. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC electronic low voltage transformers.
m. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC magnetic low voltage transformers.
n. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
o. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.
p. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
q. Specific Secondary Packs shall be available that control louver/damper motors for skylights.
r. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
s. Power (Relay) Packs and Supplies shall be the following Sensor Switch model Series:

- nPP16 (Power Pack w/ 16A relay)
- nPP16 WIFI (Power Pack w/ 16A relay, WIFI enabled)
- nEPP5 D (Power Pack w/ 5A relay and 0-10VDC dimming output)
- nSP16 (Secondary Pack w/ 16A relay)
- nSP5 2P (Secondary Pack w/ two 5A relays)
- nSP5 D (Secondary Pack w/ 5A relay and 0-10VDC dimming output)
- nPP16 ER (UL924 Listed Secondary Pack w/ 16A relay for switching emergency power circuits)
- nSP5 D ER (UL924 Listed Secondary Pack w/ 5A relay and 0-10VDC dimming output for switching emergency power circuits)
- nSP5 PCD 2W (Secondary Pack w/ 5A relay and incandescent dimming or 2-wire line voltage fluorescent dimming output)
- nSP5 PCD 3W (Secondary Pack w/ 5A relay and 3-wire line voltage fluorescent dimming output)
- nSP5 PCD MLV (Secondary Pack w/ 5A relay and magnetic low voltage dimming output)
- nSP5 PCD ELV 120 (Secondary Pack w/ 4A relay and electronic low voltage dimming output)
- nSP5 480 (Secondary Pack w/ 5A relay for switching 208/240/480 VAC loads)
- nSP5 2P LVR (Louver/Damper Control Pack)
- nSHADE (Pulse On/Off Control Pack)
- nPS 80 (Auxiliary Bus Power Supply)
- nPS 80 WIFI (Auxiliary Bus Power Supply, WiFi enabled)
E. Networked System Relay & Dimming Panels

dd. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.
ee. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
ff. Panel shall provide one 0-10VDC dimming output paired with each relay.

gg. Panel shall power itself from an integrated 120/277 VAC supply.
hh. Panel shall be capable of operating as either two networked devices or as one.
ii. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
jj. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection

kk. Power (Relay) Packs and Supplies shall be the following Sensor Switch model numbers:

- nPANEL 4 (Panel w/ four 120/277 VAC relays and four 0-10 VDC dimming outputs)
- nPANEL 2 480 (Panel w/ two dual phase relays (208/240/480 VAC) and two 0-10 VDC dimming outputs)

F. Networked Auxiliary Input / Output (I/O) Devices

a. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
b. Devices shall have two RJ-45 ports
c. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
d. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current (typically 40 or more ballasts).
e. Specific I/O devices shall have an input that read a 0-10 VDC signal from an external device.
f. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event, run a local/remote control profile, or raise/lower a dimming output

g. Specific I/O devices shall sense state of low voltage outdoor photocells
h. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based A/V control systems.
i. Specific I/O devices shall sense.

j. Auxiliary Input/Output Devices shall be the following Sensor Switch model numbers:

- nIO D (I/O device with 0-10 dimming output)
- nIO 1S or nIO RLX (I/O device with contact closure or 0-10VDC dimming input )
- nIO NLI (Input device for detecting state of low voltage outdoor photocell; sold in nIO PC KIT only)
- nIO X (Interface device for communicating with RS-232 enabled AV Touch Screens)

G. Networked LED Luminaires

a. Networked LED luminaire shall have a mechanically integrated control device
b. Networked LED luminaire shall have two RJ-45 ports
c. Networked LED luminaire shall be able to digitally network directly to other network control devices (sensors, photocells, switches, dimmers)
d. Networked LED luminaire shall provide low voltage power to other networked control devices
e. System shall be able to turn on/off LED luminaire without using a relay
f. System shall be able to maintain constant lumen output over the specified life of the LED luminaire (also called lumen compensation) by varying the input control power (and thus saving up to 20% power usage).
g. System shall indicate (via a blink warning) when the LED luminaire has reached its expected life (in hrs).
k. LED Luminaires shall be the following Lithonia model families:
   RTLED
   TLED
   VLED
   ACLED
   AL LED
   WLED
   STLED
   MINO

H. Networked System Wall Switches & Dimmers
   a. Devices shall recess into single-gang switch box and fit a standard GFI opening.
   b. Devices shall be available with zero or one integrated Class 1 switching relay.
   c. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
   d. All sensors shall have two RJ-45 ports.
   e. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
   f. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
   g. Devices with dimming control outputs can control 0-10 VDC dimmable ballasts by sinking up to 20 mA of current (typically 40 or more ballasts).
   h. Devices with capacitive touch buttons shall provide audible user feedback with different sounds for on/off, raise/lower, start-up, and communication offline.
   i. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
   j. Devices with mechanical push-buttons shall be made available with custom button labeling
   k. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.
   l. Wall switches & dimmers shall be the following Sensor Switch model numbers, with device options as specified:
      nPOD (single on/off, capacitive touch, audible user feedback)
      nPOD 2P (dual on/off, capacitive touch, audible user feedback)
      nPODR (single on/off, one relay, capacitive touch, audible user feedback)
      nPODM (single on/off, push-buttons, LED user feedback)
      nPODM 2P (dual on/off, push-buttons, LED user feedback)
      nPODM DX (single on/off, single dimming raise/lower, push-buttons, LED user feedback)
I. Networked System Graphic Wall Station
   a. Device shall have a 3.5" full color touch screen for selecting up to 8 programmable lighting control presets or acting as up to 16 on/off/dim control switches.
   b. Device shall enable configuration of lighting presets, switched, and dimmers via password protected setup screens.
   c. Device shall enable user supplied .jpg screen saver image to be uploaded.
   d. Device shall surface mount to single-gang switch box
   e. Device shall have a micro-USB style connector for local computer connectivity.
   f. Device shall have two RJ-45 ports for communication
   g. Device shall be the following Sensor Switch model number:
      nPOD GFX

J. Networked System Scene Controllers
   a. Device shall have two to four buttons for selecting programmable lighting control profiles or acting as on/off switches.
   b. Device shall recess into single-gang switch box and fit a standard GFI opening.
   c. Devices shall provide LED user feedback.
   d. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
   e. All sensors shall have two RJ-45 ports.
   f. Device shall be capable of reprogramming other devices in its zone so as to implement user selected lighting scene.
   g. Device shall be capable of selecting a lighting profile be run by the system’s upstream Gateway so as to implement selected lighting profile across multiple zones (and not just its local zone).
   h. Device shall have LEDs indicating current selection.
   i. Scene Selector device shall be the following Sensor Switch model number:
      nPODM 2S (2 Scene, push-button)
      nPODM 4S (4 Scene, push-button)
      nPODM 4S DX (4 Scene, push-button, On/Off/Raise/Lower)
      nPODM 4L DX (4 Adjustable Presets, push-button, On/Off/Raise/Lower)

K. Communication Bridges
   a. Device shall surface mount to a standard 4" x 4" square junction box.
   b. Device shall have 8 RJ-45 ports.
   c. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway.
   d. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.
   e. Device shall be careful of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power.
   This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.
   f. Communication Bridge devices shall be the following Sensor Switch model numbers:
      nBRG 8 (8 Ports)
2.4. LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device and on the software’s host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

E. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.5. MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.

E. A printable report detailing all system profiles shall be available via the software.

F. Software shall require all users to login with a User Name and Password.

G. Software shall provide at least three permission levels for users.

H. All sensitive stored information and privileged communication by the software shall be encrypted.

I. All device firmware and system software updates must be available for automatic download and installation via the internet.

J. Software shall be capable of managing systems interconnected via a WAN (wide area network).

K. Programming language and computing platform shall be HTML-based. JavaScript is not allowed.

2.6. BMS COMPATIBILITY

A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software. No additional hardware shall be required.
B. BACnet IP gateway software shall communicate information gathered by networked system to other building management systems.
C. BACnet IP gateway software shall translate and forward lighting relay and other select control commands from BMS system to networked control devices.

2.7. SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE

A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.
B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.
C. An "Energy Scorecard" shall be display that shows calculated energy savings in dollars, KWHr, or CO\textsubscript{2}.
D. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc).
E. Energy savings data shall be calculated for the system as a whole or for individual zones.
F. A time scaled graph showing all relay transitions shall be presented.
G. A time scaled graph showing a zones occupancy time delay shall be presented
H. A time scaled graph showing the total light level shall be presented.
I. User shall be able to customize the baseline run-time hours for a space.
J. User shall be able to customize up to four time-of-day billing rates and schedules.
K. Data shall be made available via a .CSV file

2.8. START-UP & SUPPORT FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.
B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.
C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.
D. All system devices shall be capable of being given user defined names.
E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.
F. All sensor devices shall have the ability to detect improper communication wiring and blink it’s LED in a specific cadence as to alert installation/startup personnel.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.
B. Wiring Method: Install cables in raceways except within consoles and cabinets and except in accessible ceiling spaces where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Comply with requirements for raceways specified in Section 26 0110 "Conduit Raceways."
3. Cables installed above accessible ceilings shall be installed in a neat workmanlike manner at right angle to structure.
4. Provide j-hooks for support of cables above accessible ceiling space.

C. 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.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, boxes, cabinets, and terminals.
B. Identify all ceiling-mounted controls with data bus number and device address.
C. Label each device cable within 6 inches (152 mm) of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
   1. Test continuity of each circuit.
B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Test each bus controller using local and remote controls.
   2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
C. Field Test Reports:
   1. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.
   2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

D. Lighting controls will be considered defective if they do not pass tests and inspections.
E. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Activate luminaires and verify that all lamps are operating at 100 percent.
3. Confirm correct communications wiring, initiate communications between DALI devices and controller/gateways, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

3.5 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 four visits to Project during other-than-normal occupancy hours for this purpose.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for five years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within five years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

3.8 OPERATIONS TRAINING

A. The contractor shall provide and implement a complete and comprehensive staff training program for all administrators, facility staff members, and teachers. This mandatory training program will provide school staff a complete understanding of how to utilize and properly operate all functions

B. The training program shall be implemented by a staff member/trainer employed by the contractor. The trainer must be factory certified to provide training on their product.

C. All staff development training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school's administrative staff and school district's staff a document listing all of the staff and faculty members who attended, received, and completed the training program.

D. Video tape training and provide electronic file of video to the Davis School District.

3.9 MAINTENANCE AND REPAIR TRAINING

A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. This mandatory training program will provide a complete understanding of how to maintain and repair the system.
B. The training program shall be implemented by a factory trained certified technician on the school site. Two (2) maintenance personnel from the Davis School District shall be trained to a "certified" level and receive a certificate.

C. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school's administrative staff and school district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.

END OF SECTION 26 0560
SECTION 26 0800
COMMISSIONING & TESTING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes work related to the commissioning and testing of electrical systems covered under Divisions 26, 27 and 28. For the specific commissioning and testing requirements of each electrical system, refer to individual electrical system specifications.

B. The commissioning authority shall review and approve all test procedures, forms, and have ability to attend the commissioning and testing activities conducted as part of the contract.

C. Where commissioning is required under other divisions that relate to electrical, such as mechanical and plumbing divisions (Division 22, 23, and 25), the contractor shall include all related electrical commissioning and testing to complete the commissioning and testing under other divisions.

D. The purpose of the commissioning and testing of electrical systems is to demonstrate that the equipment and systems are ready and safe for operation and that they are performing to the intended design level and/or intent.

1.3 ELECTRICAL SYSTEMS TO BE COMMISSIONED/TESTED

A. Commission and/or test the following electrical systems in compliance with section requirements:

1. Section 26 0070 – Electrical Connections for Equipment
2. Section 26 0156 – Variable Frequency Drives
3. Section 26 0184 – Power Conditioning Systems
4. Section 26 0435 – Protective Device Study
5. Section 26 0560 – Network Lighting Control System
6. Section 26 0923 – Lighting Control System
7. Section 26 2713 – Electricity Metering
8. Section 27 0715 – Voice and Data Communication Cabling
9. Section 27 5115 – Audio Systems
10. Section 27 5117 – Visual Systems
11. Section 27 5123 – Educational Intercommunication and Program System
12. Section 27 5213 – Projection Screens
13. Section 27 4100 – Audio and Video Systems
15. Section 28 0730 – Access Control System
16. Section 28 0720 – Intrusion Detection System
17. Section 28 2300 – Video Surveillance (Data Cabling)

1.4 DEFINITIONS

A. CTC: Certified Testing Company.


1.5 ACTION SUBMITTALS

A. Not Required.

1.6 INFORMATIONAL SUBMITTALS

A. For each system to be commissioned and tested, submit the commissioning/testing procedures, list of equipment, modes to be tested, and CTS. Include all forms, checklists, and report formats that will be used to collect, record, and demonstrate the commissioning and testing has been completed in compliance with the contract documents.

B. Qualification Data: For certified testing agency.

C. Field quality-control commissioning and testing/reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Industry standard testing equipment shall be used to perform start-up, initial check-out, prefunctional, and required functional testing applicable to the equipment or system being commissioned and/or tested.

B. Test equipment shall be of the quality and accuracy required to test and/or measure system performance with the tolerances specified or established by industry standards and shall have been calibrated within the last 12 months or as specified herein. Equipment shall be calibrated according to the recommended manufacturer intervals and when damaged, dropped, or reading are in question. Calibration tags shall be affixed or certificates of calibration available upon request.
PART 3 - EXECUTION

3.1 PREFUNCTIONAL TESTING
A. Conduct prefunctional testing as required, make remedies and adjustments to the equipment or systems as determined until the prefunctional testing has been completed with acceptable results.
B. Follow the approved prefunctional testing and check-out procedures.
C. This testing shall be completed prior to energizing and start-up of equipment and systems.
D. Submit prefunctional test reports and obtain approval from the commissioning authority prior to proceeding to start-up.

3.2 START-UP
A. Complete start-up checklists and follow the manufacturer’s published instructions for start-up of equipment and systems.
B. Submit start-up checklists, and reports with data collected during start-up.

3.3 REMEDIES AND RETESTING
A. Provide adjustments to settings, corrections to installations, and corrections to equipment and systems as required until they are operating as designed and within acceptable performance levels.
B. Complete retesting of equipment and systems where changes are made.
C. The correction and retesting sequences shall continue until acceptable performance levels and the proper operation of the equipment and systems have been met.

3.4 OWNER TRAINING
A. Conduct required owner trainings for the required equipment and systems in accordance with each section.
B. Trainings shall be video recorded, submit (3) electronic copies of the training video recording to the Owner within the O&M manuals. The Video format shall be a standard format that can be viewed on any DVD player.

3.5 DOCUMENTATION AND O&M MANUALS
A. Submit documentation as requested to demonstrate compliance with the commissioning and testing requirements of equipment and systems.
B. Include copies of commissioning and testing checklists, reports, data collected, final settings, and other pertinent data within the Owners O&M manuals.
PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes equipment for electricity metering by Owner.

1.3 DEFINITIONS
A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
B. PC: Personal computer.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: For electricity-metering equipment.
   1. Dimensioned plans and sections 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.

1.5 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Application and operating software documentation.
   2. Software licenses.
   3. Software service agreement.
4. Hard copies of manufacturer’s operating specifications, design user’s guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.7 QUALITY ASSURANCE

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

1.8 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Basis-of-Design Product: Subject to compliance with requirements, provide Continental Control Systems, LCC, WattNode BACnet energy and power meters or comparable product by one of the following:

1. E-Mon; a division of Hunt Power.
3. Osaki Meter Sales, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements for Owner's Meters:

1. Comply with UL 1244.
2. Meters used for billing shall have an accuracy of 0.5 percent of reading, complying with requirements in ANSI C12.20.
3. Modular Meter Center: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing. Size meter center to accommodate the number of meters indicated on the electrical drawings.
4. Identification: Comply with requirements in Section 26 0001 "Electrical General Provision."
5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
6. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

   a. Type: Split core.
7. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system. Owner’s protocol is BACnet.

C. Kilowatt-hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.

D. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Provide control-voltage power cables as recommended by the manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 0001 "Electrical General Provisions."

1. Equipment Identification Labels: Adhesive film labels with clear protective overlay for meters within modular meter center.

3.3 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. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

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

D. Prepare test and inspection reports.

END OF SECTION 26 2713
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to interior lighting.

1.2 SUMMARY

A. This section provides general requirements for a complete and fully operational lighting system including:

1. Interior lighting fixtures, lamps, and ballasts.
2. Exit signs.
3. Accessories
4. Light fixture support

B. Extent of interior lighting work is indicated by drawings and schedules and is specified herein.

C. Type of lighting fixtures in this section include the following:

1. Incandescent/Halogen
2. Lighting Emitting Diode (LED)

D. Related Sections:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 REFERENCES

A. Conform to Reference Standards by date of issue current on date of Contract Documents, except where a specific date is established by code.

1. ANS/NFPA 70 National Electrical Code
3. UL 57 Electrical Luminaires
4. UL 1571 Incandescent Luminaires
5. UBC Standard Section 47.1813 Luminaires
6. IES LM-79-08 Electrical and Photometric Measurements of Solid State Lighting
7. IES LM-80 Method for Measuring Lumen Maintenance for SSL Light Sources

B. Definitions:
1. BF: Ballast factor.
2. CCT: Correlated color temperature.
3. CRI: Color-rendering index.
4. HID: High-intensity discharge.
5. LER: Luminaire efficacy rating.
6. Lumen: Measured output of lamp and luminaire, or both.
7. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

A. Comply with requirements of specification section describing Submittal Procedures.

B. The authorized manufacturer’s representative for the project area shall prepare submittals for each lighting fixture type. In addition to the fixture submittals, a list shall be provided identifying the manufacturer representative for each fixture type. Provide manufacturers’ names, addresses, and telephone numbers. Requests for prior approval shall also include this information. Submittals or requests for prior approval without this information will be rejected.

C. Product Data shall indicate that light fixture lamps, and ballasts fully comply with contract documents. Data shall be submitted for each type of light fixture indicated, arranged in order of fixture designation. For standard catalog fixtures provide original product catalog sheets indicating data on features, accessories finishes, and the following:

1. Materials and dimensions of luminaires.
2. Photometric data, in IESNA format, based on certified results of laboratory tests complying with IESNA Lighting Measurements Testing & Calculation Guides of each lighting fixture type, outfitted with lamps, and accessories identical to those indicated for the light fixture as applied in the Project.
   a. Photometric data shall be certified by a qualified independent testing agency.
   b. Photometric data shall be certified by a manufacturer’s laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
3. Low voltage transformers.
4. LED power supplies.
5. Types of lamps, including manufacturer, wattage, Color Rendering index (CRI), Color Temperature in degrees Kelvin (K), color shift over life, and efficacy (lumens/watt).
6. Air and Thermal Performance Data: For air-handling light fixtures, furnish data required in “Submittals” Article in Section “Diffusers, Registers, and Grilles.”
7. Sound Performance Data: For air-handling light fixtures, indicate sound power level and sound transmission class in test report certified according to standards specified in Section “Diffusers, Registers, and Grilles.”

D. Shop Drawings shall:

1. Show details of nonstandard or custom fixtures.
2. Indicate dimensions, weights, methods of field assembly, components features, and accessories.
3. For custom fixtures, modified fixtures, or linear fluorescent fixtures mounted in continuous rows, submit scaled drawings prepared by the manufacturer showing all details of construction, lengths of runs, pendant and power feed locations, accessories, finished, and lists of materials.
4. Contractor to provide the manufacturer with accurate field dimensions where required.
5. Wiring diagrams, power and control wiring.
E. Wiring Diagrams shall detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.

F. Product samples, complete with housing, trim, specified lamp, ballast/transformer, and 8’ cord with plug shall be submitted if requested.

1.5 INFORMATIONAL SUBMITTALS

A. Not Required.

B. Coordination Drawing shall include reflected ceiling plans, sections, and other details drawn to scale and coordinating the following items:

1. Light fixtures.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches of the plane of the luminaires.
5. Structural members to which suspension systems for light fixtures will be attached.
6. Other items in finished ceiling including the following:
   a. Air outlets and inlets
   b. Speakers
   c. Sprinklers
   d. Smoke and fire detectors
   e. Occupancy sensors
   f. Access panels

C. Product Certificates shall be signed by manufacturers of lighting fixtures certifying that products comply with requirements.

D. Maintenance Data shall be provided for lighting fixtures and equipment to include in emergency, operation, and maintenance manuals specified in specifications section describing Operations and Maintenance Data.

E. Field quality control test reports.

F. Special Warranties specified in this Section.

G. Review of luminaire submittals which indicate voltage, mounting condition, or quantities shall not be considered to be approval of said voltage, mounting condition, or quantities. Contractor shall field verify voltage and actual mounting condition and method.

1.6 SUBSTITUTIONS

A. Comply with requirements of specification section describing Product Requirements.

B. Lighting fixtures are based on the fixture types and manufacturers specified. If substitution of fixtures other than those specified is desired, product information must be submitted to the Lighting Designer/Engineer 8 days prior to the close of the bid period. No requests for substitution will be accepted after this date.
C. Substitution requests shall include all information required in paragraph 1.4 – ACTION SUBMITTALS. Requests for approval shall be accompanied by a working fixture sample (including lamps, cord, and plug). Provide the name of at least one installation where each proposed substitute has been installed for at least six months. Provide the name and telephone number of the Architect, Owners’ Representative, and Lighting Designer or Engineer of record.

D. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of twelve (12) weeks. It shall be the sole responsibility of the Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.

E. When requesting a substitution, the contractor shall provide unit and extended pricing for specified luminaire, unit and extended pricing for proposed alternate, and unit and extended savings to the Owner to be realized by accepting proposed alternate. If requested, the Contractor shall provide unit pricing for each luminaire type specified to provide a baseline comparison for substitution requests.

F. If the substitution request is accepted, approval will be in the form of an addendum to the contract documents and specifications issued to all registered plan holders.

G. A maximum of two substitution requests shall be reviewed for any single fixture type. If a substitution has not been approved following this process, the Contractor shall provide the specified fixture.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.

B. 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.

C. 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.

D. Comply with NFPA 70.

E. FM Global Compliance: Lighting fixtures for hazardous location shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Luminaires, ballasts, lamps and other components and controls shall equal or exceed the requirements of all applicable state and/or municipal energy codes.

G. Designated manufacturers are listed to define the requirements for quality and function of the specified product. Equivalent or better products of other, unnamed manufacturers may be proposed for consideration by adhering to procedures set forth in this section and in Specification Section 01600 – Product Requirements.

H. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
1. Obtain Lighting Designer's/Engineer's and Architect's approval of fixtures for mockups prior to starting installation.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Remove mockups as directed.
4. Mockups evaluated on the project site may become part of the completed Work with the approval of the Owner, Lighting Designer/Engineer, and Architect if the mockup is undisturbed at the time of substantial completion.

I. Shop Drawings: Submit manufacturer's data on interior lighting fixtures. Submit dimensioned drawings of all lighting fixtures. Identify light fixtures by type and submit in alphabetical order.

1.8 COORDINATION

A. Coordinate layout and installation of light fixtures with ceiling system and other construction that penetrates ceilings or is supported by them including mechanical system, fire suppression, AV, and partition assemblies.

B. Provide all frames, supplementary support structures, hangers, spacers, stems aligner canopies, auxiliary junction boxes and other hardware as required for a complete and proper installation. Recessed fixtures shall have frames that are compatible with the ceiling systems.

C. Coordination Meetings: Meet with the ceiling installer to coordinate each light fixture mounting condition with ceiling type, and to coordinate fixture layouts in each area. Meet with the mechanical systems installer prior to fabrication and installation of ductwork. Coordinate depth and location of all light fixtures and ductwork in all areas.

1.9 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under the 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. Special Warranty for LED Lighting Fixtures: A warranty must be provided by the manufacturer made out to Owner for luminaires, covering repair or replacement of defective electrical parts (including light source and power supplies) within specified warranty period indicated below.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Glass and Plastic Lenses, Covers, Louvers, and Other Optical Parts: 10% or one dozen (whichever is less) of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: 5% of each type and rating installed. Furnish at least one of each type.
PART 2 - PRODUCTS

2.1 GENERAL

A. Provide light fixtures of types as indicated on drawings or as approved by addenda. Provide complete with, but not necessarily limited to, housings, lamps, lamp holders, reflectors, ballasts, starters, wiring, etc. Provide all light fixtures with safety latches where applicable.

B. Provide all detachable fixture parts, luminous ceiling accessories, louvers, diffusers, lenses, and reflectors with locking catches, screws, safety chains, or safety cables.

C. Provide all light fixtures and support accessories as required for a complete system.

D. Consult architectural drawings for louvers (if any) to be provided by Division 26.

2.2 MANUFACTURERS

A. Catalog numbers specified represent the full catalogue number of the fixture. The fixture size shall correspond with the wattage indicated in the Light Fixture Schedule or the actual length of the fixture as indicated on the drawings.

B. Acceptable manufacturers and full catalogue numbers are listed. The manufacturer listed shall provide complete fixtures equaling or exceeding the written specification. Verify these requirements and order fixtures as required for a complete and fully operational installation per the contract documents and per code.

2.3 GENERAL MATERIAL REQUIREMENTS

A. Fixtures shall be free of light leaks while providing sufficient ventilation of lamps to provide the required photometric performance.

B. Lamp-holders shall hold lamps securely against normal vibration and maintenance handling.

C. Light fixtures containing lamps which require protective shielding shall be furnished with a tempered glass lens or approved unbreakable lens UL listed for the application.

D. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

E. Metal Parts shall be free from burrs, sharp corners, and edges. Metal work shall be free from tool marks and dents and shall have accurate angles bent as sharply as compatible with the gauges of the required metal. Intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly. All miters shall be in accurate alignment with abutting intersection members.

F. Sheet Metal Components shall be steel, unless otherwise indicated. Components shall be formed and supported to prevent warping and sagging. Luminaires to be painted after fabrication. Finish ferrous mounting hardware and accessories to prevent corrosion and discoloration to adjacent materials.

G. Fixture hardware to comply with the following material standards: For steel and aluminum fixtures, all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel fixtures, all hardware shall be stainless steel. For bronze fixtures, all hardware shall be stainless steel or bronze.
H. Doors, Frames, and other internal access shall be smooth operating, free from light leaks under normal operating conditions, and designed to permit relamping without use of tools.

I. Provide supplemental safety device or arrange doors, frames, lenses diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Safety devices shall be detachable if necessary and shall not interfere with fixture performance, maintenance, or the seating of any fixture element. Safety device shall not be visible during normal fixture operation and from normal viewing angles.

J. Luminaires provided must have means for disconnection from power during service, as required in the NEC Article 410.

K. Reflecting Surfaces of light fixtures: Minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85%.
   2. Specular Surfaces: 90%.
   3. Diffusing Specular Surfaces: 75%.
   4. Laminated Silver Metalized Film: 90%.

L. Reflector cones shall adhere to the following criteria:
   1. Cones designed for vertically mounted lamps shall provide a minimum of 45 degree cutoff of lamp and lamp image. Cones designed for horizontally mounted lamps shall provide a minimum of 55 degree cutoff of lamp and lamp image. There shall be no visible lamp flashing in the cone.
   2. Plastic material shall not be used for reflector cones, unless otherwise specified.
   3. Cones shall not be permanently fastened to the housing or ceiling and shall be removable without tools. Retention devices shall not deform the cone or be visible from normal viewing angles.
   4. Trim shall be flush to the finished ceiling without gaps or light leaks. Where the flange trim is separate from the cone, it shall have the same finish as the reflector cone.
   5. Reflector cones shall be of uniform gauge, not less than 0.032” thick, high purity aluminum Alcoa 3002 alloy. Cones shall be free of spin marks or other defects.
   6. Manufacture cone using the Alzak process. Refer to the fixture schedule for cone color and finish (i.e. specular or diffuse) requirements. For compact fluorescent fixtures, finish shall eliminate iridescence.

M. Lenses, Diffusers, Covers, and Globes shall be 100% virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
   1. Plastic, polycarbonate and acrylic shall be UV stabilized and shall have high resistance to yellowing and other changes due to aging, exposure to heat and ultraviolet radiation.
   2. Lens Thickness shall be a minimum of 0.125” unless other thickness is indicated.
   3. Lenses shall have uniform brightness throughout the entire visible area.

N. Adjustable light fixtures shall have positive locking devices to fix the aiming angle. Fixtures shall be capable of being relamped without adjusting the aiming angle.

O. Each lighting fixture that has a lamp with an oval shape beam pattern or a spread lens that defines beam orientation shall contain lamp or lens locking devices to ensure that lamp or lens orientation is not disturbed during future lamp replacement or cleaning.

P. All fixtures and drivers must operate within the temperature limits of their design and as specified by Underwriter’ Laboratories, Inc. in the applications and mounting conditions herein.
specified.

Q. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. 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 and driver characteristics:
   a. “USE ONLY” and include specific lamp type.
   b. CCT and CRI for all luminaires.

R. Fixtures recessed in suspended ceilings where the space above the ceiling is either an air supply or return plenum shall conform to NEC Article 300-22.

S. Provide plaster frame for recessed light fixtures mounted in other than T-bar ceilings. Verify mounting with architectural reflected ceiling plan before ordering light fixtures.

T. Provide wire guards on all open strip type fixtures.

U. Fixtures for use in areas designated as damp locations shall be suitably gasketed to prevent the entrance of moisture. Provide approved wire mesh screens for ventilation opening. Dissimilar metals shall be separated by non-conductive material to prevent galvanic action.

V. Welding shall be done with electrodes and/or methods recommended by the manufacturers of the metals being welded. Welds shall be continuous, except where spot welding is specifically permitted. Welds exposed to view shall be ground flush and dressed smooth. All welds on or behind surfaces which will be exposed to view shall be done so that finished surface will be free of imperfections such as pits, runs, splatter, cracks warping, dimpling, depressions or other forms of distortion or discoloration. Remove weld spatter and welding oxides from all welded surfaces.

W. Electromagnetic-Interference Filters shall be factory installed to suppress conducted electromagnetic, interference as required by MIL-STD-461E.

2.4 INCANDESCENT/TUNGSTEN HALOGEN FIXTURES

A. Tungsten halogen is a type of incandescent light source and will be held to the same requirements as incandescent fixtures. Tungsten halogen lamp seal temperature shall not exceed 350 degrees Celsius with an ambient temperature of 25 degrees Celsius when tested per UL Bulletin 57, Paragraph 328-334. Submit certified heat test by independent testing laboratory when required in the Light Fixture Schedule.

B. Concealed parts of fixture such as lamp holders, yokes, accessory holders, and housing shall be matte black finish.

C. Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

2.5 LED FIXTURES

A. All Luminaires

1. Comply with IES LM79 and IES LM80 LED product testing procedures, and DOH energy Star requirements.
2. Luminaires shall not draw power in the off state. Luminaires with integral occupancy, motion, photo-controls, or individually addressable fixtures with external control and intelligence are exempt from this requirement. The power draw from such luminaires shall not exceed 0.5 watts when in the off state.

3. Color spatial uniformity shall be within .004 of CIE 1976 diagram.

4. Color maintenance over rated life shall be within .007 of CIE 1976.

5. Luminaires shall have a minimum CRI of 80.

6. Color shall fall within 200K of specified range.

7. LED modules shall be fully replaceable without replacing the fixture.

8. Luminaire manufacturers shall adhere to device manufacturer guidelines, certification programs, and test procedures for thermal management.

9. LED package(s)/module(s)/array(s) used in qualified luminaires shall deliver at least 70% of initial lumens, when installed in-situ, for minimum of 35,000 hours.

B. Power Supplies and Drivers

1. Power Factor 0.90 or higher

2. Operating temperature: minimum or -20ºF (129ºC) or below when used in luminaires intended for outdoor use.

3. Maximum driver case temperature not to exceed driver manufacturer recommended in-situ operation.

4. Output operating frequency: 120Hz.


6. Total Harmonic Distortion Rating: Less than 3 percent.

7. Meet electrical and thermal conditions as described in LM-80 Section 5.0.

8. Primary Current: confirm primary current with Electrical Drawings.


10. Compatibility: Certified by manufacturer for use with individually specified luminaire and individually specified control components.

11. Solid-state control components to be integral or external per each specified luminaire. Remote control gear to be enclosed in Class 1, Class 2, or NEMA 3R enclosures as required.

C. Controller and Control System

1. System electronics driver / controller to use coordinated communication protocols: DMX512, 0-10V, DALI, or proprietary as required.

2. Contractor to ensure that external control equipment is compatible with LED control requirements.

3. Provide connector types and wiring as appropriate for un-interrupted communication between devices, considering distance maximums, field obstructions, and accessibility. Ensure that connection points are optically isolated for system noise reduction.

4. For control components that are part of overall area control system see electrical Dimming Controls specification.

5. For stand-alone controlled LED systems the Light Fixture Schedule.

6. Compatibility: certified by manufacturer for use with individually specified luminaire and individually specified power supplies and/or drivers.

2.6 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. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2.7 LAMPS

A. Lamp each fixture with the proper quantity of lamps of the type specified in the Light Fixture Schedule.

B. Incandescent including Tungsten Halogen Lamps:
   1. General Service lamps: Inside frosted, 120V, filament lamps with a minimum 1000 hours rated life.

C. LED Lamps
   1. See Section 2.11, LED Fixtures.

H. LED lamp manufacturer’s to meet the requirements of Section 2.11, LED Fixtures. Unless otherwise indicated, provide all other lamps manufactured by one of the following:
   1. Osram/Sylvania
   2. Philips
   3. General Electric
   4. Ushio
   5. Venture

I. All lamps of the same type are to be provided by the same manufacturer.

2.8 SOCKETS

A. Incandescent sockets shall be porcelain for medium or mogul screw base. For other lamp types, as required by base type.

2.9 WIRING

A. All wiring shall be as required by code for fixture wiring.

B. All flexible cord wiring between fixture components or to electrical receptacles and not in wireways shall have a minimum temperature rating of 105 degrees Celsius.

C. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.

D. No internal wiring shall be visible at normal viewing angles.

2.10 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section pertaining to General Electrical Provisions, paragraph entitled Equipment anchorage, Support, Seismic Restraint, and Bracing for fixture support and bracing.

B. Where the ceiling is of insufficient strength to support the weight of the lighting fixtures, provide additional framing from building structure to support luminaires as required. Do not support
fixtures from ceiling T-Bar system.

C. Single-Stem Hangers shall be ½ –inch (13-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish shall be the same as the luminaire.

D. Twin-Stem Hangers shall be two, ¼ inch (13-mm) steel tubes with single canopy arranged to mount a single fixture. Finish shall be the same as the luminaire.

E. Rod hangers shall be 3/16-inch (5-mm) minimum diameter, cadmium-plated threaded steel rod.

F. Wires shall be ASTM A 641/A 641M, Class 3, soft temper, zinc coated steel, 12 gauge (2.68-mm).

G. Wires for humid spaces shall be ASTM A 580/A 580M, composition 302 or 304, annealed stainless steel, 12 gauge (2.68-mm).

H. Hook Hangers shall be integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

I. Aircraft Cable Support shall use cable anchorages, and intermediate supports recommended by fixture manufacturer.

J. Hangers for Pendant Industrial Fixtures shall be heavy duty No. 8 jack chain with hangers, “S” hooks, mounting, straps, and all required accessories for complete installation.

PART 3 - EXECUTION

3.1 GENERAL

A. Install interior light fixtures in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

D. Mounting height indicated in drawings from finished floor to bottom of pendant light fixture or to the center of the outlet box for all mounted light fixtures unless otherwise noted. Verify mounting heights with Architect and Lighting Designer/Engineer.

E. Mounting height may also be indicated as the length of the pendant below finished ceiling.
F. Provide all necessary hanging or mounting devices and accessories for all fixtures. Verify the types needed for various ceiling conditions. Plaster rings shall be provided where required.

G. Verify weight and mounting method of all fixtures prior to ordering and provide suitable support. Coordinate with General Contractor for fixtures that require additional blocking or support. Fixture mounting assemblies shall comply with all local seismic codes and regulations.

H. Refer to architectural reflected ceiling plans for coordination of light fixture locations with mechanical and fire safety equipment. Where conflicts occur, coordinate with Architect and Lighting Designer/Engineer prior to installing any of the systems.

I. In accessible suspended ceilings, fixture wiring connection, including equipment grounding conductor, is to be through use of 72-inch flexible conduit from a rigidly supported junction box.

J. Wire per requirements of branch circuit installation. Properly ground each fixture.

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

L. Light fixtures located in recessed ceilings with a fire resistive rating of 1 hour or more shall be enclosed in an approved fire resistive rated box equal to that of the ceiling.

M. Install fixtures with vent holes free of air blocking obstacles.

N. Contractor shall be responsible for adjusting aperture flanges or rings on all recessed fixtures to be flush with the finished ceiling. Fixture trim shall completely conceal ceiling opening.

O. Adjust variable position lampholders for proper lamp position prior to fixture installation.

3.3 FIXTURE SUPPORT


B. Provide all necessary hanging or mounting devices for all fixtures, verify the type needed for various ceiling conditions. Plaster rings shall be provided where required.

C. Ceiling Fixture Support: Where ceiling is of insufficient strength to support weight of light fixtures installed, provide additional framing from building structure to support as required.

D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.

2. Electrical Contractor is to provide and install locking clips for all fixtures installed in suspended ceilings that are UL listed for the application. The locking clip is to be attached to the fixture with a sheet metal screw or similar device and secured to the main or supporting T-bar runner to guarantee a secure installation. Clips shall be located at or near fixture corners.

3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

**E. Suspended Lighting Fixture Support:**

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
3. Brace suspended luminaires installed near ducts or other elements so that they do not swing into obstructions.
4. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
5. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

**F.** Provide four slack No. 9 safety wire hangers or threaded rods for each recessed mounted fixture. Secure form corners of each fixture and fasten to structure above, independent of ceiling system. Locate supports not more than 6 inches from fixture corners.

**G.** Metal decking shall not be pierced for luminaire support.

**H.** Wall mounted light fixtures shall be supported from four-square outlet box plaster ring and from wall at non-feed end with two 1/4-inch toggle bolts for gypsum board walls or 1/4-inch bolts to pre-set inserts for concrete wall.

### 3.4 IDENTIFICATION

**A.** Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.5 INCANDESCENT FIXTURES

**A.** Surface or Pendant Type: Attach to heavy formed steel straps attached to the outlet box by means of threaded stems with locknuts, or directly to the outlet box where the fixture is specifically so designed.

**B.** Recessed Type in Accessible Ceilings: Mount in frames suitable for the ceiling with the recessed portion of the fixture securely supported from the ceiling opening by use of a metal trim ring.

**C.** Recessed Type in Non-accessible Ceilings: As specified for mounting in accessible ceilings, except provide access to wiring through the ceiling opening for the fixture.

### 3.6 LED FIXTURES

**A.** Adhere to manufacturer’s installation guidelines regarding proper thermal management.

### 3.7 LIGHTING CONTROL

**A.** Provide branch circuiting in coordination with lighting control requirements of specification.
section describing Lighting Control Equipment and as indicated on Electrical Drawings.

3.8 PROTECTION, CLEANING AND ADJUSTING

A. Protect installed and non-installed fixtures from damage during construction period.

B. Remove protective plastic covers from light fixtures and fixture diffusers only after construction work, painting and clean-up are completed. Remove, clean and reinstall all dirty lamps, reflectors and diffusers.

C. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer for cleaning Alzak reflectors and other surfaces.

D. Make final adjustment of aimable light fixtures and adjustable light settings under the direction of the Lighting Designer during a scheduled period of time prior to the completion of the project, after normal business hours if required. Include all equipment and personnel expenses including overtime required for focusing.

E. Fixtures, reflectors, and accessories which are damaged, blemished or impregnated with fingerprints shall be replaced at the contractor’s expense. All finishes shall be unmarred upon project completion.

3.9 FIELD QUALITY CONTROL

A. Coordinate all testing procedures and schedule with the specification section describing Commissioning Agent – Demonstration and Training. All testing is to be documented with test procedures, results and initials of witnessing personnel and submitted to Commissioning Agent.

B. Coordinate inspection and testing of Light Fixtures with specification section describing – Lighting Control Equipment.

C. Inspect each installed fixture for damage. Replace damaged fixtures and components.

D. Replace all burned out lamps or inoperative lamps at the end of construction prior to Owner occupancy.

E. Advance Notice: Give dates and times for field tests.

F. Provide instruments to make and record test results.

G. Test as follows:

1. Verify proper operation, switching and phasing of each fixture after installation.
2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation. Verify normal transfer to generator and retransfer to normal.
3. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to the lighting system, retest to demonstrate compliance with standards.

H. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until unit operates properly.

3.10 SPARE PARTS
Acrylic Diffusers: Provide a spare acrylic diffusers and/or glass for each light fixture type and one for each additional unit for each 10 fixtures. The quantity of any single type need not exceed 10.

3.11 WARRANTY

A. Lamps: Warranty incandescent lamps for a period of two months from substantial completion.

END OF SECTION 26 5100
SECTION 26 5200

EXTERIOR AREA LIGHTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to exterior area lighting.

1.2 DESCRIPTION OF WORK:

A. Extent of exterior area lighting work is indicated by drawings and schedules and is specified herein.

1.3 QUALITY ASSURANCE:

A. STANDARDS: Refer to Section 26 0001 - Electrical General Provisions and other sections as applicable.

B. SHOP DRAWINGS: Submit manufacturer's data on exterior area lighting items including but not necessarily limited to poles, brackets, light fixtures, fuse, fuseblocks, etc. Submit dimensioned drawings of all pole and lighting fixtures. Include information with interior and exterior building lighting fixtures.

PART 2 – PRODUCTS

2.1 GENERAL:

A. Provide exterior lighting fixtures of types as indicated on drawings or as approved by addenda.

2.2 LIGHT FIXTURES:

A. Refer to Section 26 0510 - Interior Lighting for requirements for exterior light fixtures, lamps, drivers, etc.

2.3 POLES:

A. Provide poles and all accessories including but not necessarily limited to anchor bolts, templates for anchor bolt pattern, brackets, bolts, etc. Provide handhole and cover at base of each pole. Provide poles which have been primed and painted at the factory. Provide poles, anchor bolts, etc. in sizes as recommended by manufacturer to withstand windloadings.

2.4 CONCRETE BASES:

A. Provide 3000 psi class concrete, forms, steel reinforcement, tie wires, etc. as required. See
drawings for details.

2.5 GROUND RODS:

A. See Section 26 0452 – Grounding for ground rod requirements.

2.6 FUSEHOLDER, FUSES, AND BREAK-A-WAY RECEPTACLES:

A. Provide fuseholders with break-a-way receptacles equivalent to Bussmann Tron Waterproof Fuseholders and Break-A-Way Receptacles in the base for all phase conductors and materials. Neutral fuse holder will use a shorting fuse insert. Provide Bussmann KTK-R fuses in ratings to suit respective applications and sized in accordance with all manufacturer's recommendations.

PART 3 – EXECUTION

3.1 GENERAL:

A. Install exterior area lighting in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.2 INSTALLATION METHODS:

A. Set all poles plumb. Use belt slings or ropes to raise and set poles to protect finish. Repair nicks and scratches to match original surface.

B. Locate fuseholder at handhole. Provide fuse blanks in all neutral conductors.

C. Grounding: Provide one ground rod for each light pole. Connect ground rod to pole by means of an NEC-sized grounding conductor and all additional grounding as required.

3.3 CONCRETE BASES:

A. Provide concrete bases for light poles in accordance with details on drawings. Grout and hand-rub all concrete to a uniform smooth finish.

3.4 SPARE PARTS:

A. FUSES: Provide three spare fuses for each type and size used.

3.5 WIRING METHODS:

A. No common neutral multi-wire circuits will be used to feed area lighting. Provide dedicated neutral wire for each circuit indicated.

END OF SECTION 26 5200
SECTION 27 0526
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding labeling.

1.3 DEFINITIONS
A. BCT: Bonding conductor for telecommunications.
B. EMT: Electrical metallic tubing.
C. TGB: Telecommunications grounding busbar.
D. TMGB: Telecommunications main grounding busbar.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS
A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
   1. Ground and roof rings.
   2. BCT, TMGB, TGBs, and routing of their bonding conductors.
B. Qualification Data: For Installer, installation supervisor, and field inspector.
C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Result of the ground-resistance test, measured at the point of BCT connection.
   b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Installer 2, who shall be present at all times when Work of this Section is performed at Project site.

2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Comply with J-STD-607-A.

2.2 CONDUCTORS

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. Harger Lightning and Grounding.
2. Panduit Corp.
3. Tyco Electronics Corp.

B. Comply with UL 486A-486B.

C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 6 AWG.
D. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG [26 kcmils (13.3 sq. mm)] and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. Bare Copper Conductors:

4. Bonding Cable: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

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

1. Burndy; Part of Hubbell Electrical Systems.
2. Chatsworth Products, Inc.
3. Harger Lightning and Grounding.
4. Panduit Corp.
5. Tyco Electronics Corp.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

D. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.

E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

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. Chatsworth Products, Inc.
2. Harger Lightning and Grounding.
3. Panduit Corp.

B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, [1/4 by 4 inches (6.3 by 100 mm)] in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a [4-inch (100-mm)] clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. TGB: Predrilled rectangular bars of hard-drawn solid copper, [1/4 by 2 inches (6.3 by 50 mm)] in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm long, with) stainless-steel or copper-plated hardware for attachment to the rack.

2.5 LABELING

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

2. HellermannTyton.
3. Panduit Corp.

B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with J-STD-607-A.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 10 AWG and smaller and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 3/0 AWG.

2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 3/0 AWG.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Connections to Structural Steel: Welded connectors.

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm.)

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.

2. Install without splices.
3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in PVC conduit sized in accordance with the NEC until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMBG and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
   1. Use crimping tool and the die specific to the connector.
   2. Pretwist the conductor.
   3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG [168 kcmils (85 sq. mm)] unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.
H. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.

I. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

J. Electronic System Equipment: Bond equipment chassis of other electronic system equipment including fire alarm, intrusion detection, access control, and educational school intercom and program systems to the TGB or TMGB located in their respective communication rooms.

3.7 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
   a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
   a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.
D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 27 0526
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Telecommunications mounting elements.
   2. Backboards.
   3. Telecommunications equipment racks and cabinets.

B. Related Requirements:
   1. Section 260111 "Cable Trays" for cable trays and accessories.
   2. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
   3. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS


B. LAN: Local area network.

C. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. 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 location 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.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Certificates: For equipment frames from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of 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. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment frames shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

2.3 EQUIPMENT FRAMES

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

1. ADC.
2. Belden Inc.
3. Cooper B-Line.
5. Hubbell Premise Wiring.
6. Leviton Commercial Networks Division.
7. Middle Atlantic Products, Inc.
8. Ortronics, Inc.
9. Panduit Corp.
10. Siemon Co. (The).
11. Tyco Electronics Corporation; AMP Products.

B. General Frame Requirements:

1. Distribution Frames: Freestanding, 2-post, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Module Dimension: Width compatible with EIA 310-D standard, 19-inch (480-mm) panel mounting.
3. Finish: Manufacturer's standard, baked-polyester powder coat.

C. Floor-Mounted Racks: Modular-type, steel 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. Cable Management for Equipment Frames:

1. Vertical Cable Management: Metal or plastic, 6” wide channel, front and back of each rack, with hinged cover. Metal if utilized shall be baked-polyester powder coat finish.
2. Horizontal Cable Management: Plastic with a minimum height of two rack units each, cover, end caps, front and back of each rack.

2.4 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. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
8. Cord connected with 15-foot (4.5-m) line cord.
9. Rocker-type on-off switch, illuminated when in on position.
11. 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 330 V.

2.5 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communication Systems" for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:
   1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
   2. Ground Bus Bar: Copper, minimum 1/4-inch-thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
   3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with J-STD-607-A.

2.6 LABELING

A. Comply with TIA/EIA-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

3.1 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.

3.2 PRE-CONSTRUCTION MEETING: Attend a Pre-Construction Meeting with the Logan City School District to review installation standards and to discuss layout of racking and equipment prior to doing any work.

3.3 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 the Logan City School District IT Department and the Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with the Logan City School District IT Department, 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. Seismically brace floor-mounted racks with C-channel supports extending from each rack to the wall. Refer to Section 260072, “Electrical Supports and Seismic Restraints”.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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.

1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.
3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A.

B. Comply with requirements in Section 099123 "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/EIA-606-A for Class 2 level of administration including optional identification requirements of this standard.

D. Labels shall be preprinted or computer-printed type.

END OF SECTION 27 1100
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pathways.
   2. UTP cable.
   3. 8.3/125-micrometer, optical fiber cabling.
   4. Cable connecting hardware, patch panels, and cross-connects.
   5. Cabling identification products.

B. Related Sections:
   1. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.3 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.

1.4 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.

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.

C. TOPOLOGY: Each telecommunications closet (IDF) shall be wired to the main cross-connect (MDF). Bridged taps, which create multiple appearances of the same cable at several distribution points, are not acceptable. There is a limitation of two hierarchical levels of backbone cross-connects, so that interconnections between any two telecommunications closets must not pass through more than three cross connect facilities.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 ACTION SUBMITTALS

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

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration drawings and printouts.
3. Wiring diagrams to show typical wiring schematics including the following:

   b. Patch panels.
   c. Patch cords.

4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.8 CLOSEOUT SUBMITTALS

A. 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.

B. Warranty documentation:
   1. Include copy of final, executed warranties.
   2. Contact information.

C. Data map.

D. Test results.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Patch-Panel Units: One of each type.
   2. Connecting Blocks: One of each type.

1.10 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 (copper and optical fiber), 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. Testing Agency Qualifications: An NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. 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: 450 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

1.11 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.

1.12 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.

1.13 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.14 WARRANTY

A. The system shall provide a 20-year warranty for applications, parts, and labor.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

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 cable tie slots for fastening cable ties to brackets.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

C. Cable Trays: Refer to section 260111, “Cable Trays”.

D. Conduit and Boxes: Comply with requirements in Section 260135 "Electrical Boxes and Fittings."
   1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
   2. Flexible metal conduit shall not be used.
2.2 **BACKBOARDS**

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

2.3 **UTP CABLE**

A. Basis of Design Product: Subject to compliance with requirements, provide Mohawk GigaLAN Cat 6E UTP or comparable product by one of the following:

1. Hitachi Cable America, Inc
2. Superior Essex Inc.
3. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four pair UTP, covered with a thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6E.
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, complying with UL 1666.
5. Jacket colors:
   b. School Intercom: Orange.
   c. CCTV: Purple.
   d. Data: Blue.
   e. Energy: Green.

2.4 **UTP CABLE HARDWARE**

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

1. Hubbell
2. Leviton Voice & Data Division.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cable shall be terminated with connecting hardware of same category or higher.

C. 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. Number of Jacks per Field: One for each four-pair UTP cable indicated.

D. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
E. Patch Cords: Provide factory-made, 4-pair cables. 80% of the patch cords shall be 36-inch (914-mm) and the remaining 20% shall be 60-inch (1524-mm) for each patch panel to patch panel connection; terminated with 8-position modular plug at each end. 120-inch (3048-mm) patch cords shall be provided at desk-top (user) locations.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6E performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall be color-coded to match color of system for circuit identification.

2.5 OPTICAL FIBER CABLE

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

1. Berk-Tek; a Nexans company.
2. CommScope, Inc.
3. Corning Cable Systems.
4. General Cable Technologies Corporation.
5. Mohawk; a division of Belden CDT.
6. Nordex/CDT; a subsidiary of Cable Design Technologies.
7. Optical Connectivity Solutions Division; Emerson Network Power.
8. Superior Essex Inc.
9. SYSTIMAX Solutions; a CommScope Inc. brand.
10. 3M.
11. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: multimode mode, 50/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable, for 10 GIG operation.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492-CAAA for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   b. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
5. Maximum Attenuation: 0.65/0.5 db/km at 1310/21550 nm.

C. Jacket:

2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

D. Underground Applications:

1. Must be specifically approved for use by the Logan City School District.
2. Cables shall be moisture tolerant in a method approved by the District.
2.6 OPTICAL FIBER CABLE HARDWARE

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

1. ADC.
3. Berk-Tek; a Nexans company.
4. Corning Cable Systems.
5. Dynacom Corporation.
6. Hubbell Premise Wiring.
7. Molex Premise Networks; a division of Molex, Inc.
8. Nordex/CDT; a subsidiary of Cable Design Technologies.
9. Optical Connectivity Solutions Division; Emerson Network Power.
10. Siemon Co. (The).

B. Light Guide Interface Unit (LIU): Rack-mounted modular enclosure with fan-out assemblies that provides cross-connect and interconnect capabilities for terminating fiber optic building cables and each end. All termination shall be TIA/EIA-568SC type as specified in the SP-2840A Standards. Provide LC connectors only for terminations.

C. Patch Cords: Factory-made, dual-fiber cables in 72-inch (1800-mm) lengths for connections between owner-provided HUB to LIU.

D. Cable Connecting Hardware:

2. Quick-connect, simplex and duplex, Type LC connectors. Insertion loss not more than 0.75 dB.

2.7 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communication Systems" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.8 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.9 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.
D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 PRE-CONSTRUCTION MEETING: Attend a Pre-Construction Meeting with the Logan City School District to review installation standards prior to doing any work.

3.3 WIRING METHODS

A. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters. Conceal raceway 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 Section 260135 "Electrical Boxes and Fittings."

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.

3.4 INSTALLATION OF PATHWAYS

C. Coordinate cable connection hardware installations and specialty arrangements with layout drawings and with requirements specified for communications equipment rooms. If Drawings are explicit enough, these requirements may be reduced or omitted.

D. 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.

E. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

F. Comply with requirements in Section 260135 "Electrical Boxes and Fittings" for installation of conduits and wire ways.

G. Install manufactured conduit sweeps and long-radius elbows whenever possible.

H. 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 (76 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

I. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.5 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. 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 (12 mm) 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 or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:
   1. Comply with BICSI TDMM and TIA/EIA-569-A 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:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
   3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
   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 (76 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
   5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
   6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.6 FIRESTOPPING
   A. Comply with requirements in Section 078413 "Penetration Firestopping."
   B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
   C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 GROUNDING
   A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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.

3.8 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 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 Section 099123 "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/EIA-606-A for Class 2 level of administration including optional identification requirements of this standard.

D. Comply with requirements in Section 271500 "Communications Horizontal Cabling" for cable and asset management software.

E. 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.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Provide three (3) hard copies to owner; insure that copies are delivered as follows: one (1) to Utility Services, one (1) to Architectural Services, and one (1) to the School. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect each drawing with rigid frame and clear plastic cover.

G. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. 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.
3. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.

4. Meet with Logan City School District Telecommunication personnel and coordinate labeling requirements prior to installation.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.9 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:


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/EIA-568-B.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/EIA-568-B.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 single mode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.

2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

D. 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.
E. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

F. End-to-end cabling will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.10 MAINTENANCE AND REPAIR TRAINING

A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. Trainer shall be a Level 2 installer.

B. This mandatory training program will provide a complete understanding of how to maintain and repair the system including but not limited to:

1. Installation.
2. Wiring.
4. Administration.
5. Trouble shooting/repair.

C. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school's administrative staff and school district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.

D. Provide quick reference guides.

END OF SECTION 27 1300
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. UTP cabling.
   2. Cable connecting hardware, patch panels, and cross-connects.
   3. Telecommunications outlet/connectors.
   4. Cabling system identification products.

B. Related Requirements:
   1. Section 27 1300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS


B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. LAN: Local area network.

G. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

H. RCDD: Registered Communications Distribution Designer.

I. UTP: Unshielded twisted pair.
1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
   2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   3. Cabling administration drawings and printouts.
   4. Wiring diagrams to show typical wiring schematics, including the following:
      a. Patch panels.
      b. Patch cords.
   5. Patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For installer, qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

C. Warranty documentation:
1. Include copy of final, executed warranties.
2. Contact information.

D. Data map.
E. Test results.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Patch-Panel Units: One of each type.
   2. Device Plates: Ten of each type.

1.9 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 (copper and fiber), 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. Testing Agency Qualifications: An NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1.11 WARRANTY

A. The system shall provide a 20-year warranty for applications, parts, and labor.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a “permanent link,” a term that is used in the testing protocols.
1. TIA/EIA-568-B.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.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

D. Topology: Star Configuration.

2.2 PERFORMAENCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 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.


2.3 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

2.4 UTP CABLE

A. Basis-of-Design Product: Subject to compliance with requirements, provide Mohawk GigaLAN Cat 6E UTP or comparable product by one of the following:

1. Hitachi Cable America, Inc.
2. Superior Essex Inc.
3. Tyco Electronics Corporation: AMP Products.

B. Description: 100-ohm, four-pair UTP, covered with a thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6E.
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, complying with UL 1666.

5. Provide shielded cables for all wireless access points.

6. Jacket colors:
   b. School Intercom: Orange.
   c. CCTV: Purple.
   d. Data: Blue.
   e. Energy: Green.

2.5 UTP CABLE HARDWARE

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

   1. Hubbell
   2. Leviton Commercial Networks Division.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. 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. Number of Jacks per Field: One for each four-pair UTP cable indicated.
   2. Rating: Category 6E.

D. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular Category 6e receptacle units with integral IDC-type terminals.

E. Patch Cords: Provide factory-made, 4-pair cables. 80% of the patch cords shall be 36-inch (914-mm) and the remaining 20% shall be 60-inch (1524-mm) for each patch panel to patch panel connection; terminated with 8-position modular plug at each end. 120-inch (3048-mm) patch cords shall be provided at desk-top (user) locations.

   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6E performance. Patch cords shall have latch guards to protect against snagging.
   2. Patch cords shall be color-coded to match color of system for circuit identification.

2.6 TELECOMMUNICATIONS OUTLET/CONNECTORS

Workstation Outlets: One, two, or three port-connector assemblies as indicated on drawings mounted in single faceplate.

1. Metal Faceplate: Brushed Stainless steel, complying with requirements in Section 260140 "Wiring Devices."
2. For use with snap-in jacks accommodating UTP, work area cords.
   a. Flush mounting jacks, positioning the cord at a 45-degree angle.
3. Legend: Machine printed, in the field, using adhesive-tape label, clear with black letters.

2.7 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with J-STD-607-A.

2.8 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.9 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 PRECONSTRUCTION MEETING

A. Attend a Preconstruction Meeting with the Logan City School District to review installation standards prior to doing any work.
3.3  WIRING METHODS

A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile accessible ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 1".
3. Comply with requirements in Section 260111 "Cable Trays."

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.

3.4  INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. 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 (12 mm) from the point of termination to maintain cable geometry.

D. Group connecting hardware for cables into separate logical fields.

E. 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:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

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 (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.
3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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.

E. Ground shields of all shielded twisted pair cables in accordance with all manufacturer’s written instructions.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 2.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Section 099123 "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/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

D. 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.

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. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner. Provide three (3) hard copies to owner. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect with rigid frame and clear plastic cover.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. 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.

3. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.

4. Meet with Logan City School District Telecommunications personnel and coordinate labeling requirements prior to installation.

5. For cable drop/jack for each wireless access point, provide a Kory label on the ceiling grid nearest the radio indicating the distribution rack and circuit number.

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/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.8 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:


2. Visually confirm Category 6e, marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.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 and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.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. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connector 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.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

3.10 MAINTENANCE AND REPAIR TRAINING

A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. Trainer shall be a Level 2 installer.

B. This mandatory training program will provide a complete understanding of how to maintain and repair the system including but not limited to:

1. Installation.
2. Wiring.
4. Administration.
5. Trouble shooting/repair.

C. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.
D. Provide quick reference guides.

END OF SECTION 27 1500
SECTION 27 5115

AUDIO SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install complete and operational sound systems as described in Contract
      Documents to include all equipment and materials, whether specifically mentioned herein
      or not, to ensure complete and operational systems.
   2. Assist Audio / Video Consultant with final inspection and equalization of system and
      provide necessary test equipment for sound system and partition noise isolation tests.
      Correct problems found at time of final inspection of system.

B. Related Requirements:
   1. Division 26:
      a. Raceways, boxes, and fittings.
   2. Audio / Video Consultant will perform final inspection, system balance, and equalization.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate final inspection schedule with Audio / Video Consultant three weeks minimum
      before Consultant's final inspection.

1.3 SUBMITTALS

A. Informational Submittals:
   1. Itemized list of equipment to be supplied with product data sheets
   2. Shop drawings
   3. System programming

B. Closeout Submittals:
   1. Include following in Operations And Maintenance Manual:
      a. Operations and Maintenance Data:
         1) Equipment Manufacture’s manual:
            a) Sound system operation and maintenance instructions.
            b) List of equipment provided, including portable equipment, showing
               make, model, and serial number.
      b. Warranty Documentation:
         1) Include copy of final, executed warranties.
         2) Contact information.
      c. Record Documentation:
         1) Software and Programming: Copies of all manufacturers’ software used for
            programming various components and functions of the system shall be
            furnished to the Owner:
            a) Original source codes and compiled codes used for system control,
               audio setup and any other computerized functions of the system
including screen layout generation, configuration and layouts and any other related computer files shall also be furnished to the Owner.

b) In each and every case, all programming, code generation, configuration files, layout files and any other software and/or code written and generated of the setup and operation of this system are the property of the Owner of the system and not of the consultant, contractor or integrator.

2) Testing results.
3) Hardware locations and configurations.

1.4 QUALITY ASSURANCE

A. Qualifications: Requirements is not limited to following:

1. Installers Qualifications:
   a. Approved Installers. Specified installers are to both furnish and install components of sound system.
      1) Marshall Industries: (801) 266-2428.
      2) Poll Sound: (801) 261-2500.
      3) Professional Systems Technology, Inc. (801)649-6696
      4) TPI: (801)702-8242
      5) Bids submitted by non-pre-qualified bidders will not be accepted.
   b. Installer’s Qualifications:
      1) The work of this section will be contracted to a single firm, referred to as the Sound Installer for undivided responsibility.
      2) The Sound Installer must be experienced in the installation of professional sound systems and have completed within the past five years at least five sound system projects of a size and scope comparable to the project described herein.
      3) The Sound Installer shall have capabilities and in-house facilities for installation, shop fabrication and repair service of professional sound systems.
      4) The Sound Installer shall have on his full-time payroll at least one staff engineer having five years minimum experience as an Audio and Video engineer. In place of a qualified staff engineer, the Sound Installer may retain a consulting engineer to direct the project. Prior to bid acceptance, the qualifications of the consulting engineer shall be submitted for the approval of the Consultant. Said staff or consulting engineer shall:
         5) Provide all technical liaisons between the Sound Installer and the Consultant.
         6) Represent the Sound Installer at meetings and conferences, and be present at the job site for final inspection/ 
         7) Be responsible for supervision of all technical and engineering work required executing the contract, and in particular, approving and signing of all shop drawings.
         8) Must be a dealer or distributor of equipment included in bid and provide documents from manufacturers stating such.
         9) Outline the general scope of past project, normal staffing levels, and union status of shop and field installation personnel.
         10) List a minimum of three (3) projects of similar scope successfully completed, indicating the location, type of system installed, total contract amount, date completed, and include persons and telephone number to contact.
         11) Submit confirmation of current state or local contracting licenses, as required to perform the work under this section.

2. Manufacturer’s Qualifications:
   a. Firms regularly engaged in manufacture of sound system components and accessories for more than 5 years.
1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Refer to drawings for descriptions and quantities of extra material required. Except for major head-end equipment, at least 3% spare materials but not less than one whole unit of each type of input or output device shall be provided whether indicated or not.

1.6 WARRANTY

A. Special Warranty:
   1. Provide complete warranty repair or replacement for one year at no cost to Owner, except in case of obvious abuse.
   2. Honor component warranties for term established by Manufacturer, if greater than one year.
   3. Activate all manufacturers’ equipment warranties in Owner’s name to commence on the date of acceptance.
   4. Contractor shall respond, excluding weekends and holidays, within 24 hours to any warranty service calls. If equipment cannot be repaired within 24 hours of service visit, the contractor shall provide “loaner” equipment to the facility at no charge. Response shall be defined as a visit to the site; a phone call is not acceptable. The response time of 24 hours is defined to mean one day, not three business days.
   5. If, during the warranty period, any component is out of service for more than one week due to unavailability of parts or service, supply and install an identical new component. If an identical component is not available, substitute equivalent equipment, but only with approval of the Owner.
   6. When equipment is removed from the school for warranty repair or replacement, provide documentation filed with the school including description of part, serial number, estimated return date of equipment, and technician contact information.

PART 2 - PRODUCTS

2.1 SYSTEM

A. Product are specified on drawings.

PART 3 - EXECUTION

3.1 FIELD COOPERATION

A. Cooperate at all times, and to the fullest extent, with all trades during work to the end that lost time, work stoppages, interference, and inefficiencies do not occur.

3.2 SHOP DRAWINGS SUBMITTALS

A. Submit shop drawings of systems prior to fabrication:
   1. System functional block drawings including all equipment names and model numbers.
2. Provide full scale drawings of all custom plates and panels indicating exact lettering, critical dimensions, and finish.
3. Provide a list of test equipment, including manufacturer, description and model number of the test equipment expected to be employed in the test and adjustment of the systems.

3.3 EXAMINATION

A. Verification Of Conditions:
   1. Verify compliance with following items before beginning work of this Section.
      a. No cables spliced.
      b. Isolated grounds run back to electrical panel from all equipment cabinets.
      c. Specified conduit, cables, speaker enclosures and equipment cabinets are properly installed.

3.4 PRECONSTRUCTION MEETING: Attend a Preconstruction Meeting with the Logan City School District to review installation standards prior to doing any work.

3.5 WIRING METHODS

A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile accessible ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 3/4".
3. Comply with requirements in Section 260111 "Cable Trays."

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.

3.6 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. 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 (12 mm) from the point of termination to maintain cable geometry.

D. Group connecting hardware for cables into separate logical fields.

E. 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:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
   3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
   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 (76 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.7 FIRESTOPPING
A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING
A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with J-STD-607-A.
C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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.

3.9 IDENTIFICATION
A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Administration Class: 2.
   2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
B. Comply with requirements in Section 099123 "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/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
D. 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.
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. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner. Provide three (3) hard copies to owner. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect with rigid frame and clear plastic cover.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. 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.
3. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.
4. Meet with Logan City School District Telecommunications personnel and coordinate labeling requirements prior to installation.

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/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.10 INSTALLATION

A. Equipment
1. Provide new equipment that shall meet or exceed the latest published specifications of the manufacturer in all respects as specified in the Equipment List on the drawings.
2. Supply the latest model, available at the time of bidding, of each piece of equipment.
3. Color of devices shall be reviewed and approved by the architect.

B. Speakers:
1. Maintain uniform polarity in speakers and wiring.
2. Employ no positive stop in rotation of speaker volume controls. Controls shall be capable of continuous rotations in either direction.
3. Neatly mount speaker grilles, panels, connector plates, control panels, etc., tight, plumb, and square unless indicated otherwise on drawings.
4. Provide adequate fastenings and supports with a safety load factor of at least three and adhere to all seismic requirements.

C. Equipment Cabinet:
1. Install vent panels at top and bottom of equipment cabinets and between components where possible for maximum ventilation. Locate amplifiers at top of cabinet. Locate digital signal processors below amplifiers, separated by several vent panels.
2. Securely fasten equipment plumb and square in place. Utilize all fastening holes in front of cabinet.
3. Securely fasten in place equipment that is not rack mounted, including relays and other small components. Do not use sticky-back tape.
4. Install balancing / isolation transformer when balanced and unbalanced components are connected.
5. Wire XLR-type connections with pin 2 hot, pin 1 shield.
6. Connect powered components to 120 VAC outlets on voltage suppressor power bars. Do not connect to outlets on other components.
7. Identification:
   a. Legibly identify user-operated system controls and system input / output jacks using engraved, permanently attached laminated plastic plates or imprinted Lexan labels. Label equipment and controls within equipment cabinets using similar labels or printed labels from a label maker or laser printer.
   b. Affix label to rack panel inside cabinet listing name and telephone number of installer. Appropriate warranty instructions may be included.

D. Cables:
1. Leave sufficient service loops of uniform length on cables to allow for future equipment replacement.
2. Make parallel connections or splices on standard barrier terminal blocks using spade lugs, or on equipment terminals using appropriate connection type. Do not attach more than three spade lugs under any one screw terminal.
3. Strip and heat shrink tubing on wires installed in Euroblock or Phoenix connectors so 1/16 inch (2 mm) of wire is exposed outside connector when wire contacts back of connector:
   a. Secure wires using screwdriver with blade of same width as screw slot and handle 3/4 inch (19 mm) minimum diameter and of length to allow applying sufficient torque to prevent wires from becoming disconnected.
4. Terminate conductors with proper mating connectors:
   a. Do not use adapters.
   b. Use proper crimp tool as recommended by Connector Manufacturer.
5. Male CAT-6 connectors shall be grey-smoked or blue-smoked RJ-45's.
   a. After installing RJ-45 connectors, test CAT-6 cables for shorts, opens, and cross-pairing with two-piece wire-mapping continuity tester.
6. Secure cables to equipment cabinet with wire ties to ensure neat installation:
7. Ground both ends of each cable shielded within equipment cabinet only. Ground microphone cables only at mixer.
8. Label within 6" of both ends of cables with source and destination. Use HellermannTyton Tag 49L-105 or similar label types.
   a. Example 1: PULPIT MIC: MIXER IN 1.
   b. Example 2: DSP OUT B: CC1 AMP IN.
   c. Group all cables according to the signals being carried. In order to reduce signal contamination, form separate groups for the following cables:
      1) Microphone cables
      2) UTP, sound system control, telephone, video or ATC cables
      3) Loudspeaker cables
      4) Antenna cables
      5) Power cables at least a foot away from the above.
9. Install no cable with a bend radius less than that recommended by the cable manufacturer.
10. Grommets and other devices shall be used to insure the integrity of the cable now and in the future.
11. Bundle multiple cables in Tech Flex if in full view of the owner.
12. Use plenum rated cable tie-wraps and supports when conditions require it.
13. All cables shall be routed in conduit and cable tray. Size raceways in accordance with NEC conductor fill requirements.

E. Equipment installed in millwork shall be cut in with the upmost care and aesthetic value. Verify that adequate cooling for the electronics is sufficient.
F. Power cables shall be plugged into TVSS power strips and not into other electronics.

G. During installation if surfaces become damaged intentionally or unintentionally they shall be repaired in a professional manner.

3.11 FIELD QUALITY CONTROL

A. Field Tests:
   1. Installer Testing:
      a. After completion of installation but before inspection by Audio / Video Consultant, perform following:
         1) Conduct system tests and make necessary corrections for proper system operation including, but not limited to, following:
            a) Output level uniformity.
            b) Polarity.
            c) Shock, strain excited hum, and oscillation.
            d) Clipping, hum, noise, and RFI in all system configurations.
            e) Speaker line impedances.
            f) Loose parts and poor workmanship.
         2) Sweep speaker systems with high-level sine wave noise source. Correct causes of buzzes or rattles related to speakers or enclosures. Notify Contractor and Audio / Video Consultant of external causes of buzzes or rattles.
         3) Rough Balance: Balance system well enough that it can be used before final inspection.
      b. Complete documentation and submit to consultant 5 days prior to Substantial Completion.
         1) Written notification with settings and as-built drawings.

B. Field Inspections:
   1. Audio / Video Consultant Inspection And Equalization:
      a. Coordinate final inspection schedule with Audio / Video Consultant two weeks minimum before Consultant's final inspection.
      b. Have copy of redlined record documents available 5 days prior to Substantial Completion.
      c. Have loose equipment (microphones, cables, etc.) available at time of inspection.
      d. Assist Audio / Video Consultant in final inspection of completed system.
      e. Provide following test equipment in good working order:
         1) Laptop computer, 100 MHz Pentium or better, with 16 bit sound card, software, and interfacing adapters for microprocessor controlled equipment in system.
         2) 1/3 octave real-time audio spectrum analyzer with SPL meter, and precision microphone.
         3) Digitally generated random pink noise generator, 20Hz-20KHz, minimum 2 hour repetition rate or 10 minutes minimum of equivalent signal recorded on compact disc.
         4) Direct reading audio impedance meter, minimum 3 frequencies, and 10 percent accuracy.
         5) Digital Volt-Ohmmeter.
         6) Audio oscillator, variable frequency, 20 Hz to 20 KHz.
         7) Compact disc player, or equal, with pre-recorded speech and music program material.
         8) Necessary chargers, cables, test leads, adapters, and other accessories for test equipment.
         9) Tools and spare parts for making adjustments and corrections to system.
10) Blank cassette tape for testing cassette recorder.
11) CAT-5 / RJ-45 continuity tester similar to Ideal 62-200 or Amprobe DCT-300.

f. Correct minor items so Audio / Video Consultant may certify satisfactory completion during his visit.

3.12 SYSTEM ACCEPTANCE

A. System acceptance tests shall not be performed until the initial system checkout has been completed. The system acceptance tests shall be supervised by the Consultant and shall consist of the following:
   1. Take a physical inventory of all equipment on site and compare to equipment lists in the contract documents.
   2. Demonstrate the operation of all system equipment.
   3. Both subjective and objective tests will be required by the Consultant to determine compliance with the specifications. Provide test equipment specified by the Consultant for these tests.
   4. Provide all final, "as-built" drawings, manuals, video (DVD format) and other required documents.

B. In the event that the systems are not completely installed or further adjustment is required, or defective equipment must be repaired or replaced, tests may be suspended or continued at the option of the Consultant. The Consultant’s return trip shall be paid for by the installer prior to the Consultant’s return.
   1. If the need for further adjustments becomes evident during the demonstration and testing, continue work until the installation operates properly. Included in the continued work shall include, but not be limited to, changes to or installation of resistive pads, readjustment of loudspeaker aiming, adjustment of system equalizers, programming changes to the control system, if in the judgment of the Consultant, these adjustments are required.
   2. If acceptance of the system is delayed because of defective equipment or because the equipment does not fulfill this specification, reimburse the Consultant for all time and expenses of the Consultant for these tests during any extensions of the acceptance-testing period.

3.13 CLEANUP AND REPAIR

A. Upon completion of the work, remove all refuse and rubbish from and about the premises daily, and shall leave the relevant areas and equipment clean and in an operational state. Repair any damage caused to the premises by the installation activities, at no cost to the Owner.

3.14 PROTECTION OF WORK

A. During the installation, and up to the date of final acceptance, protect finished and unfinished work against damage and loss. In the event of such damage or loss, replace or repair such work at no cost to the Owner.

3.15 OPERATIONS TRAINING

A. At the completion of the project, the contractor shall provide and implement a complete and comprehensive staff training program for all administrators, facility staff members, and teachers
done on site. This mandatory training program will provide school staff a complete understanding of how to utilize and properly operate all functions. Two (2) complete and separate operations training programs shall be provided, one for classroom systems and the other for non-classroom systems.

B. At three (3) months from completion of the project, the contractor shall provide and implement a complete and comprehensive follow-up/refresher training program for all administrators, facility staff member, and teachers done on site. Two (2) complete and separate follow-up/refresher training programs shall be provided, one for classroom systems and the other for non-classroom systems.

C. The training program shall be conducted by certified factory trained implemented by a staff member/trainer employed by the contractor. The trainer must be factory certified to provide training on their product.

D. All staff development training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the staff and faculty members who attended, received, and completed the training program.

E. Video tape training and provide electronic file of video to the Logan City School District.

F. Provide quick reference guides.

3.16 MAINTENANCE AND REPAIR TRAINING

A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. Two (2) complete and separate operations training programs shall be provided, one for classroom systems and the other for non-classroom systems.

B. This mandatory training program will provide a complete understanding of how to maintain and repair the system including but not limited to:

1. Installation.
2. Wiring.
4. Administration.
5. Trouble shooting/repair.

C. The training program shall be implemented by a factory trained certified technician on the school site. Six (6) maintenance personnel from the Logan City School District shall be trained to a “certified” level and receive a certificate.

D. Additional Digital Signal Processor and Touch Screen Controls Training: In addition to the training described above, provide training for the digital signal processor and touch screen controls by a certified factory-trained technician who is employed directly by the factory. Include all costs in bid including, but not necessarily limited to airfare, hotels, meals, rental car, parking, gasoline, travel time, training time, etc. Six (6) maintenance personnel from the Logan City School District shall be trained to a “certified” level and receive a certificate.

E. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school
district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.

F. Provide quick reference guides.

END OF SECTION 27 5115
PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install complete and operational sound systems as described in Contract Documents to include all equipment and materials, whether specifically mentioned herein or not, to ensure complete and operational systems.
   2. Assist Audio / Video Consultant with final inspection and equalization of system and provide necessary test equipment for sound system and partition noise isolation tests. Correct problems found at time of final inspection of system.

B. Related Requirements:
   1. Division 26:
      a. Raceways, boxes, and fittings.
   2. Audio / Video Consultant will perform final inspection, system balance, and equalization.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate final inspection schedule with Audio / Video Consultant three weeks minimum before Consultant's final inspection.

1.3 SUBMITTALS

A. Informational Submittals:
   1. Itemized list of equipment to be supplied with product data sheets
   2. Shop drawings
   3. System programming

B. Closeout Submittals:
   1. Include following in Operations And Maintenance Manual:
      a. Operations and Maintenance Data:
         1) Equipment Manufacturer’s manual:
            a) Sound system operation and maintenance instructions.
            b) List of equipment provided, including portable equipment, showing make, model, and serial number.
      b. Warranty Documentation:
         1) Include copy of final, executed warranties.
         2) Contact information.
      c. Record Documentation:
         1) Software and Programming: Copies of all manufacturers’ software used for programming various components and functions of the system shall be furnished to the Owner:
            a) Original source codes and compiled codes used for system control, audio setup and any other computerized functions of the system including
screen layout generation, configuration and layouts and any other related computer files shall also be furnished to the Owner.

b) In each and every case, all programming, code generation, configuration files, layout files and any other software and/or code written and generated of the setup and operation of this system are the property of the Owner of the system and not of the consultant, contractor or integrator.

2) Testing results.
3) Hardware locations and configurations.

1.4 QUALITY ASSURANCE

A. Qualifications: Requirements is not limited to following:

1. Installers Qualifications:
   a. Approved Installers. Specified installers are to both furnish and install components of sound system.
   1) Marshall Industries: (801) 266-2428.
   2) Poll Sound: (801) 261-2500.
   3) Professional Systems Technology, Inc. (801)649-6696
   4) TPI: (801)702-8242
   5) Bids submitted by non-pre-qualified bidders will not be accepted.
   b. Installer’s Qualifications:
   1) The work of this section will be contracted to a single firm, referred to as the Sound Installer for undivided responsibility.
   2) The Sound Installer must be experienced in the installation of professional sound systems and have completed within the past five years at least five sound system projects of a size and scope comparable to the project described herein.
   3) The Sound Installer shall have capabilities and in-house facilities for installation, shop fabrication and repair service of professional sound systems.
   4) The Sound Installer shall have on his full-time payroll at least one staff engineer having five years minimum experience as an Audio and Video engineer. In place of a qualified staff engineer, the Sound Installer may retain a consulting engineer to direct the project. Prior to bid acceptance, the qualifications of the consulting engineer shall be submitted for the approval of the Consultant. Said staff or consulting engineer shall:
   5) Provide all technical liaisons between the Sound Installer and the Consultant.
   6) Represent the Sound Installer at meetings and conferences, and be present at the job site for final inspection.
   7) Be responsible for supervision of all technical and engineering work required executing the contract, and in particular, approving and signing of all shop drawings.
   8) Must be a dealer or distributor of equipment included in bid and provide documents from manufacturers stating such.
   9) Outline the general scope of past project, normal staffing levels, and union status of shop and field installation personnel.
   10) List a minimum of three (3) projects of similar scope successfully completed, indicating the location, type of system installed, total contract amount, date completed, and include persons and telephone number to contact.
   11) Submit confirmation of current state or local contracting licenses, as required to perform the work under this section.

2. Manufacturer’s Qualifications:
   a. Firms regularly engaged in manufacture of sound system components and accessories for more than 5 years.
1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Refer to drawings for descriptions and quantities of extra material required. Except for major head-end equipment, at least 3% spare materials but not less than one whole unit of each type of input or output device shall be provided whether indicated or not.

1.6 WARRANTY

A. Special Warranty:
   1. Provide complete warranty repair or replacement for one year at no cost to Owner, except in case of obvious abuse.
   2. Honor component warranties for term established by Manufacturer, if greater than one year.
   3. Activate all manufacturers’ equipment warranties in Owner’s name to commence on the date of acceptance.
   4. Contractor shall respond, excluding weekends and holidays, within 24 hours to any warranty service calls. If equipment cannot be repaired within 24 hours of service visit, the contractor shall provide “loaner” equipment to the facility at no charge. Response shall be defined as a visit to the site; a phone call is not acceptable. The response time of 24 hours is defined to mean one day, not three business days.
   5. If, during the warranty period, any component is out of service for more than one week due to unavailability of parts or service, supply and install an identical new component. If an identical component is not available, substitute equivalent equipment, but only with approval of the Owner.
   6. When equipment is removed from the school for warranty repair or replacement, provide documentation filed with the school including description of part, serial number, estimated return date of equipment, and technician contact information.

PART 2 - EXECUTION

2.1 SYSTEM DESCRIPTION

A. Products are specified on drawings.

PART 3 - EXECUTION

3.1 FIELD COOPERATION

A. Cooperate at all times, and to the fullest extent, with all trades during work to the end that lost time, work stoppages, interference, and inefficiencies do not occur.

3.2 SHOP DRAWINGS SUBMITTALS

A. Submit shop drawings of systems prior to fabrication:
   1. System functional block drawings including all equipment names and model numbers.
2. Provide full scale drawings of all custom plates and panels indicating exact lettering, critical dimensions, and finish.
3. Provide a list of test equipment, including manufacturer, description and model number of the test equipment expected to be employed in the test and adjustment of the systems.

3.3 EXAMINATION

A. Verification Of Conditions:
   1. Verify compliance with following items before beginning work of this Section.
      a. No cables spliced.
      b. Isolated grounds run back to electrical panel from all equipment cabinets.
      c. Specified conduit, cables, speaker enclosures and equipment cabinets are properly installed.
      d. Location and angle of speaker cabinets.

3.4 PRECONSTRUCTION MEETING:

   Attend a Preconstruction Meeting with the Logan City School District to review installation standards prior to doing any work.

3.5 WIRING METHODS

A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile accessible ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 3/4".
   3. Comply with requirements in Section 260111 "Cable Trays."

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.

3.6 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. 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 (12 mm) from the point of termination to maintain cable geometry.

D. Group connecting hardware for cables into separate logical fields.

E. 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:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
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 (76 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.7 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with J-STD-607-A.
C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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.

3.9 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Administration Class: 2.
   2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
B. Comply with requirements in Section 099123 "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/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
D. 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.
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. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner. Provide three (3) hard copies to owner. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect with rigid frame and clear plastic cover.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. 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.
3. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.
4. Meet with Logan City School District Telecommunications personnel and coordinate labeling requirements prior to installation.

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/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.10 INSTALLATION

A. Equipment

1. Provide new equipment that shall meet or exceed the latest published specifications of the manufacturer in all respects as specified in the Equipment List on the drawings.
2. Supply the latest model, available at the time of bidding, of each piece of equipment.
3. Color of devices shall be reviewed and approved by the architect.

B. Equipment Cabinet:

1. Install vent panels at top and bottom of equipment cabinets and between components where possible for maximum ventilation. Locate amplifiers at top of cabinet. Locate digital signal processors below amplifiers, separated by several vent panels.
2. Securely fasten equipment plumb and square in place. Utilize all fastening holes in front of cabinet.
3. Securely fasten in place equipment that is not rack mounted, including relays and other small components. Do not use sticky-back tape.
4. Install balancing / isolation transformer when balanced and unbalanced components are connected.
5. Connect powered components to 120 VAC outlets on voltage suppressor power bars. Do not connect to outlets on other components.
6. Identification:
   a. Legibly identify user-operated system controls and system input / output jacks using engraved, permanently attached laminated plastic plates or imprinted Lexan labels.
Label equipment and controls within equipment cabinets using similar labels or printed labels from a label maker or laser printer.

b. Affix label to rack panel inside cabinet listing name and telephone number of installer. Appropriate warranty instructions may be included.

C. Cables:
1. Leave sufficient service loops of uniform length on cables to allow for future equipment replacement.
2. Terminate conductors with proper mating connectors:
   a. Do not use adapters.
   b. Use proper crimp tool as recommended by Connector Manufacturer.
3. Secure cables to equipment cabinet with wire ties to ensure neat installation:
4. Label within 6" of both ends of cables with source and destination. Use HellermannTyton Tag 49L-105 or similar label types.
   a. Group all cables according to the signals being carried. In order to reduce signal contamination, form separate groups for the following cables:
      1) Microphone cables
      2) UTP, sound system control, telephone, video or ATC cables
      3) Loudspeaker cables
      4) Antenna cables
      5) Power cables at least a foot away from the above.
5. Install no cable with a bend radius less than that recommended by the cable manufacturer.
6. Grommets and other devices shall be used to insure the integrity of the cable now and in the future.
7. Bundle multiple cables in Tech Flex if in full view of the owner.
8. Use plenum rated cable tie-wraps and supports when conditions require it.
9. Cable shall be routed in raceway and cable tray. Size raceway in accordance with all NEC conductors fill requirements.

D. Equipment installed in millwork shall be cut in with the upmost care and aesthetic value. Verify that adequate cooling for the electronics is sufficient.

E. Power cables shall be plugged into TVSS power strips and not into other electronics.

F. During installation if surfaces become damaged intentionally or unintentionally they shall be repaired in a professional manner.

3.11 FIELD QUALITY CONTROL

A. Field Tests:
1. Installer Testing:
   a. After completion of installation but before inspection by Audio / Video Consultant, perform following:
      1) Conduct system tests and make necessary corrections for proper system operation including, but not limited to, following:
         a) Output level uniformity.
         b) Polarity.
         c) Shock, strain excited hum, and oscillation.
         d) Clipping, hum, noise, and RFI in all system configurations.
         e) Loose parts and poor workmanship.
      2) Rough Balance: Balance system well enough that it can be used before final inspection.
   b. Complete documentation and submit to consultant 5 days prior to Substantial Completion.
1) Written notification with settings and as-built drawings.

B. Field Inspections:
   1. Audio / Video Consultant Inspection And Equalization:
      a. Coordinate final inspection schedule with Audio / Video Consultant two weeks
         minimum before Consultant's final inspection.
      b. Have copy of redlined record documents available 5 days prior to Substantial
         Completion.
      c. Have loose equipment (microphones, cables, etc.) available at time of inspection.
      d. Assist Audio / Video Consultant in final inspection of completed system.
      e. Provide following test equipment in good working order:
         1) Field strength
         2) Video test signal generator
         3) Blu Ray and DVD with pre-recorded speech and music program material.
         4) Necessary chargers, cables, test leads, adapters, and other accessories for
            test equipment.
         5) Tools and spare parts for making adjustments and corrections to system.
      f. Correct minor items so Audio / Video Consultant may certify satisfactory completion
         during his visit.

3.12 SYSTEM ACCEPTANCE

A. System acceptance tests shall not be performed until the initial system checkout has been
   completed. The system acceptance tests shall be supervised by the Consultant and shall
   consist of the following:
   1. Take a physical inventory of all equipment on site and compare to equipment lists in the
      contract documents.
   2. Demonstrate the operation of all system equipment.
   3. Both subjective and objective tests will be required by the Consultant to determine
      compliance with the specifications. Provide test equipment specified by the Consultant
      for these tests.
   4. Provide all final, "as-built" drawings, manuals, video (DVD format) and other required
      documents.

B. In the event that the systems are not completely installed or further adjustment is required, or
   defective equipment must be repaired or replaced, tests may be suspended or continued at the
   option of the Consultant. The Consultant's return trip shall be paid for by the installer prior to
   the Consultants return.
   1. If the need for further adjustments becomes evident during the demonstration and
      testing, continue work until the installation operates properly. Included in the continued
      work shall include, but not be limited to, changes to or installation of resistive pads,
      readjustment of loudspeaker aiming, adjustment of system equalizers, programming
      changes to the control system, if in the judgment of the Consultant, these adjustments
      are required.
   2. If acceptance of the system is delayed because of defective equipment or because the
      equipment does not fulfill this specification, reimburse the Consultant for all time and
      expenses of the Consultant for these tests during any extensions of the acceptance-
      testing period.
3.13 CLEANUP AND REPAIR
A. Upon completion of the work, remove all refuse and rubbish from and about the premises daily, and shall leave the relevant areas and equipment clean and in an operational state. Repair any damage caused to the premises by the installation activities, at no cost to the Owner.

3.14 PROTECTION OF WORK
A. During the installation, and up to the date of final acceptance, protect finished and unfinished work against damage and loss. In the event of such damage or loss, replace or repair such work at no cost to the Owner.

3.15 OPERATIONS TRAINING
A. At the completion of the project, the contractor shall provide and implement a complete and comprehensive staff training program for all administrators, facility staff members, and teachers done on site. This mandatory training program will provide school staff a complete understanding of how to utilize and properly operate all functions. Two (2) complete and separate operations training programs shall be provided, one for classroom systems and the other for non-classroom systems.

B. At three (3) months from completion of the project, the contractor shall provide and implement a complete and comprehensive follow-up/refresher training program for all administrators, facility staff member, and teachers done on site. Two (2) complete and separate follow-up/refresher training programs shall be provided, one for classroom systems and the other for non-classroom systems.

C. The training program shall be implemented by a staff member/trainer employed by the contractor. The trainer must be factory certified to provide training on their product.

D. All staff development training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the staff and faculty members who attended, received, and completed the training program.

E. Video tape training and provide electronic file of video to the Logan City School District.

F. Provide quick reference guides.

3.16 MAINTENANCE AND REPAIR TRAINING
A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. Two (2) complete and separate operations training programs shall be provided, one for classroom systems and the other for non-classroom systems.

B. This mandatory training program will provide a complete understanding of how to maintain and repair the system including but not limited to:
   1. Installation.
   2. Wiring.
   4. Administration.
5. Trouble shooting/repair.

C. The training program shall be implemented by a factory trained certified technician on the school site. Two (2) maintenance personnel from the Logan City School District shall be trained to a “certified” level and receive a certificate.

D. Additional Digital Signal Processor and Touch Screen Controls Training: In addition to the training described above, provide training for the digital signal processor and touch screen controls by a certified factory-trained technician who is employed directly by the factory. Include all costs in bid including, but not necessarily limited to airfare, hotels, meals, rental car, parking, gasoline, travel time, training time, etc. Six (6) maintenance personnel from the Logan City School District shall be trained to a “certified” level and receive a certificate.

E. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.

F. Provide quick reference guides.

END OF SECTION 27 5117
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
1. The drawings and general provisions of the Contract Documents apply to this Section.

1.2 SUMMARY
A. This section includes a fully operational IP platform for district and school internal communications system incorporating school safety notifications and general communications including but not limited to the following:

1. The platform shall provide complete internal communications employing state of the art IP Technology including the minimum functions listed.
   a. Two-way Loud Speaking Internal Intercommunications.
   b. Bell Event announcement
   c. Emergency announcement that will override any pre-programmed zones assuring that all Emergency/Lockdown etc., are heard at each and every speaker location.
   d. Capability of prerecording emergency announcements that can simply be activated by a simple Soft Key or via a dedicated call-switch.
   e. Atomic Time Synchronization with Class Change Tones utilizing multiple, programmable schedules for each zone.
   f. District wide, Emergency, All and zone live voice paging
   g. District wide, emergency, all and zone paging for pre-recorded audio – tones, music and voice.
   h. Web-based, permission driven user interface.

2. The system shall support a minimum of 1000 level priorities which shall be user definable, allowing each end point to place a minimum of 5 different priority calls at the same time.

3. Any authorized administrator shall be able to call from outside the school into any classroom, zone or entire school directly via the School District supplied SIP enabled Telephone Network. This shall allow remote monitoring, call-in annunciation and two-way conversation from outside the facility as well as paging into the system. (Compliance with NEMA Standard SB-40 for emergency communications in K-12 Schools)

4. Authorized system users shall be able to create a minimum of twenty (20) automated sequences with emergency instructions, emails and relay activations and replay them. Automated message strings shall be, manually played from a single-button access on the console, on a SIP connected telephone, a panic button or from the web interface.

5. Paging and two-way loud speaking features shall be accessible from any system console or SIP connected telephone.
6. The platform shall synchronize its system time to the network timeserver or a web-based time server.
7. Each single school installation shall be locally survivable for intercom, paging bells, and emergencies such as lockdown, even when the district connection is unavailable.
8. This specification establishes a minimum level of quality, features, and performance for individual components as well as the integrated system.

1.3 DEFINITION OF TERMS
A. Installer(s): Shall refer to the person, persons, or company who or which actually contracts to perform the work specified herein.

1.4 SUBMITTALS
A. Product data for each component.
B. Shop Drawings: Prior to proceeding with the work: Provide detailed equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection, and a complete schedule of all equipment and materials with associated manufacturers cuts sheets which are to be used.
   1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals to facilitate installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components and levels throughout system.
   2. Artwork drawings and lists indicating proposed nameplate nomenclature and arrangements for control panels and plug panels prior to fabrication reflecting equipment used.
   3. Each drawing shall have a descriptive title and all sub-parts of each drawing shall be labeled. All drawings shall have the name and locations of the project, Systems Contractor’s name in the title block.
   4. Details and descriptions of any other aspect of the system, which must differ from the contract documents due to field conditions or equipment, furnished.
C. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.
D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
E. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.
F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.
G. Maintenance Data: For equipment to be included in maintenance manuals specified in Division 1.

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EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS
a. Record of Owners equipment-programming option decisions.

b. All instructions necessary for proper operation and manufacturers instructions.

c. “Proof of Performance” information.

d. Manufacturer’s maintenance information.

e. Copies of non-proprietary computer programs and system set up disks documenting all programmable features of the installed system.

H. Record Drawings: Prior to final acceptance, provide three (3) complete sets of drawings indicating all cable numbers and construction details in accordance with the actual system installation. Revise all shop drawings to represent actual installation conditions. These Record Drawings will be used during “Final Acceptance Testing”.

I. System Training: Submit the following information describing the training programs and system trainers as outlined in paragraph 1.6 of this specification and in accordance with Division 1 specifications.

   a. Include with the submittal a preliminary staff development training program in outline form for review and approval by the owner’s representative.

   b. Include with the submittal a current copy of the trainer’s certification from the manufacturer that certifies and identifies the trainer(s) who are eligible to provide training and support for the project.

   c. Include with the submittal a current copy of trainer’s need’s assessment form which will be reviewed with the owner’s designated representative for the system’s preliminary system programming and configuration.

   d. Include with the submittal copies of all documentation used to identify for the owner those participants attending and completing the training programs.

J. A copy of the manufacturer’s standard statement of warranty proving all equipment provided for the school communications network is covered with the required five-year warranty shall be included with the project submittal. This statement of warranty shall be provided on the manufacturer’s stationary.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section. Provide the following with in thirty (30) days after notification to proceed:

   1. Provide a list of installations that the Installer has specifically installed for verification by the Owner. Random installations from other vendors and/or Installers shall not be accepted. The Installer, not its employees, must meet these qualifications.

   2. The Installer shall be bondable.

   3. The Installer shall demonstrate to the satisfaction of the Owner or his representative that he has:

      a. Adequate plant and equipment to pursue the work properly and expeditiously.
b. Adequate staff and technical experience to implement the work.

c. Suitable financial status to meet the obligations of the work.

d. Technically capable and factory trained service personnel at a local service facility to provide routine and emergency service for all products used in this project.

B. Any Contractor, who intends to bid on this work and does not meet the requirements of the “Quality Assurance” paragraph(s), shall employ the services of a “Installer” who does meet the requirements and who shall provide the equipment, make all connections and continuously supervise the installation. A subcontractor so employed as the “Installer” must be acceptable to the Architect/Engineer. The “Installer” shall be identified within thirty (30) days of notification to proceed for acceptance by the Architect/Engineer.

C. Because the life expectancy of this type of communications system normally exceeds ten years, the owner expects continuity from the service provider. If the installing/servicing company has not been an authorized provider of the manufacturer’s product for at least ten years, the following is required:

1. A list of (2) systems manufacturers of which they currently are authorized service providers where the relationship exceeds five years.

2. A letter from the manufacturer outlining the details of changes in service providers over the last five years and what actions they will take to ensure continuity in service to the customer.

D. Each major component of equipment shall have the manufacturer’s name, address and model number on a plate securely affixed in a conspicuous place. NEMA code ratings, UL Label, or other data that is die-stamped into the surface of the equipment shall be easily visible.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

F. Comply with NFPA 70.

G. Comply with NEMA Standard SB-40 for Emergency Communications in K-12 schools.

H. Comply with UL 60950.

1.6 OPERATIONS TRAINING

A. The contractor shall provide and implement a complete and comprehensive staff training program for all administrators, facility staff members, and teachers. This mandatory training program will provide school staff a complete understanding of how to utilize and properly operate all functions.

B. The training program shall be implemented by a staff member/trainer employed by the contractor. The trainer must be factory certified to provide training on their product.

C. All staff development training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the staff and faculty members who attended, received, and completed the training program.

D. Video tape training and provide electronic file of video to the Logan City School District.
1.7 MAINTENANCE AND REPAIR TRAINING

A. The contractor shall provide and implement a complete and comprehensive training program for all maintenance personnel. This mandatory training program will provide a complete understanding of how to maintain and repair the system.

B. The training program shall be implemented by a factory trained certified technician on the school site. Two (2) maintenance personnel from the Logan City School District shall be trained to a “certified” level and receive a certificate.

C. All training is to be coordinated through the owner’s designated representative. As training sessions are completed, the trainer will provide the school’s administrative staff and school district’s staff a document listing all of the maintenance personnel who attended, received, and completed the training program.

1.8 WARRANTY

A. Provide a manufacturer’s five-year warranty of the school communications network equipment against defects in material and workmanship. This warranty will cover all electronic equipment, as well as analog clocks, speakers, and call-in switches. If any defects are found within the warranty period, the defective equipment shall be replaced at no cost (equipment only); a one year warranty shall be provided for labor.

B. A copy of the manufacturer’s standard statement of warranty proving all equipment provided for the school communications network is covered with the required five-year warranty shall be included with the project submittal. This statement of warranty shall be provided on the manufacturer’s stationary. The standard five-year warranty is an important element in establishing a standard in quality. Manufacturers who circumvent the five-year warranty by offering special “extended warranties” that are not part of their normal published warranty will not be accepted.

C. Contractor shall respond, excluding weekends and holidays, within 24 hours to any warranty service calls. If equipment cannot be repaired within 24 hours of service visit, the contractor shall provide “loaner” equipment to the facility at no charge.

D. Make available a service contract offering continuing factory authorized service of the system after the initial warranty period.

1.9 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Telecenter manufactured by Rauland-Borg Corp through Marshall Industries, Inc., 3800 W. 2100 S., Salt Lake City, UT 84120 or comparable products as may be approved by addendum.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS
A. The platform shall utilize state of the art IP Technology, Call-in Notification, School Safety Paging and Evacuation tones, IP infrastructure, Atomic Time Synchronization with Class Change Tones utilizing multiple, programmable schedules for each zone, Two-way hands-free Internal Intercommunications and Paging, and Program Distribution. The system shall be easy to learn and operate. All standard programming shall be web based and user friendly to allow the system administrator the ability to easily program system features.

B. Provide complete and satisfactorily operating district/school communications and district/school safety as described herein, using materials and equipment of types, sizes, ratings, and performances as indicated. Use materials and equipment that comply with referenced standards and manufacturers’ standard design and construction, in accordance with published product information. Coordinate the features of all materials and equipment so they form an integrated system, with components and interconnections matched for optimum performance of specified functions.

C. The platform shall be a single electronic system consisting of a minimum of 10 intercom channels per facility, (classroom) IP speakers, corridor speakers, inside and outside horns, call-in switches, SIP phone integration, and district wide integration for paging, emergency notifications, and configuration.

D. The platform shall lend itself to expansion by simple addition of hardware modules.

E. The platform shall directly connect to the WAN/LAN without the need for a separate server at each school location. Configuration, including bell schedules, calendars, and emergency sequences can remotely be created, changed, stored and downloaded to the system by an authorized user from a browser-based interface.

F. The platform shall provide the ability to initiate school safety paging announcements, evacuation tones and take cover tones from any telephone within the facility or outside the facility to any other location within the facility or district.

G. The platform shall provide the ability to selectively communicate or monitor individual classrooms in emergency situations from any telephone within the facility or outside the facility to any other location within the facility; all communication within the classroom shall be hands free and will not require any interaction by the classroom user.

H. IP addressable speaker modules for individual rooms shall be system programmable and may be assigned any two, three, four, five or six digit number as well as name and description. Any extension may be reassigned at any time.

I. IP-enabled two-way voice communication shall be available from any provided telephone or administrative console through any speaker in the system. This shall allow hands-free communication to any classroom or any individual loudspeaker unit. A programmable pre-announce tone shall sound immediately before the intercom path is opened and a supervisory tone shall continue to sound at regular intervals when speaker monitoring is active, complying fully with all privacy legislation. Pre announce tone and supervisory tones shall be disabled during designated emergencies automatically.

J. Integrated Master Clock with unlimited schedules, unlimited events, and automatic Daylight Savings time correct. Up to 5 schedules may be active on any given day for each school. User shall be able to select from 25 standard included tones or unlimited user created and uploaded audio files for class change signaling and messaging. In addition, scheduled events shall include relay actions and email notifications. The platform shall allow control of the bell schedules via the district WAN/LAN without the need for a separate computer at the school.
location. Bell schedules can remotely be created, changed, stored and downloaded to the system by an authorized user from a browser-based interface.

K. Integration with existing intercom system. During multi-phase construction, the new communications system shall maintain class change signaling and zone paging across the building. A SIP gateway may be needed to integrate the new communications system with the existing Rauland Telecenter V.

2.2 EQUIPMENT AND MATERIAL

A. Server Software TCUSWENT2G
1. Provides district wide paging, bell event scheduling, emergency notification and configuration for entire district.
2. Reports on feature usage, system activity, etc. shall be available from the district-wide web interface.
3. Ability to perform configure system and initiate system features via district wide web based interface.
4. The software has the ability to sync system time to the Atomic Clock Signal or to the school’s or districts network time server
5. The software will provide a web-browser to deliver district wide emergency paging, pre-recorded messages and tones from any authorized computer in the facility or the district. The software must be capable of automatically notifying district personnel via the WAN of an alarm condition.
6. The software can automatically broadcast page emergency instructions via associated system hardware throughout an entire district when an alarm (e.g. lockdown, lockout, security, fire) is initiated via the web-based interface. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems
7. The software shall support VoIP Telecenter Campus Controllers for a minimum of 1000 facilities.
8. The software shall support a minimum of 50,000 IP Speaker modules, district wide.

B. VoIP Single Campus Controller Rauland-Borg Telecenter Series TCC2000 with the following features and capabilities:
1. Provides call routing for paging and intercom for a single facility
2. System shall connect to the district provided Telephone Network via a SIP connection.
3. The VX Works based Operating System and system programming database shall be stored in non-volatile flash memory. The Operating System can be easily upgraded through configuration without requiring replacement of any chips.
4. Support a flexible numbering plan allowing two, three, four, five, or six digit extensions.
5. SIP interface to a district provided Telephone Network shall be capable of allowing connected phones to display classroom call-ins, answer internal intercom call-ins, make pages and change priorities of call-ins in progress.
6. Direct Dialing, two-way amplified voice intercom between any provided telephone or admin console and speaker without the use of a press-to-talk or talk-listen switch.

7. Ability to place up to 5 levels of call-in from any call in switch per area.

8. The ability to answer intercom call-ins registered at pre-selected telephones.

9. The ability to automatically escalate incoming call-ins to an alternate administrative console or SIP telephone or group of telephones if they remain unanswered for a predetermined amount of time.

10. The ability to remotely locate IP Campus Controller. The controller shall not need direct connection to any classroom via home run or distributed wiring. It shall communicate solely through the IP LAN network.

11. Single button access from any telephone on the system to distribute emergency announcements within the facility to all or select locations equipped with speakers. Emergency announcements originating from any assigned administrative telephone shall have priority over all regular system functions.

12. Store a minimum of 48 hours of Bell Event Schedules, all emergency notification sequences as well as facility wide configuration.

13. System has the ability to sync system time to the Atomic Clock Signal or to the school’s or districts network time server.

14. System’s SIP Interface shall provide:
   a. Audio paging access from any telephone to any single intercom speaker, zone (group) of intercom/paging speakers, or all speakers/paging horns throughout the entire facility.
   b. Single button access from any telephone on the system to initiate alarm signals within the facility to all or select locations equipped with speakers. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative telephone shall have priority over all regular system functions.

15. The system will have the ability to utilize a web-browser and USB microphone to deliver district wide live emergency paging, pre-recorded messages and tones from any authorized computer in the facility or the district. The system must be capable of automatically notifying district personnel via the WAN of an alarm condition.

16. The system can automatically broadcast page emergency instructions throughout an entire school when an alarm (e.g. lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.

C. IP addressable Modules TCC2011:

1. System shall provide multiple IP addressable modules for intercom, paging and relay activation.
   a. All modules are POE 802.3af compliant
   b. All Modules support DHCP
   c. All Modules connect to network with a single RJ45 connector

2. IP Speaker Module shall interface to school’s data network, a speaker, and multiple call switches.
   a. A minimum of 5 levels of call-in can be placed from an IP Speaker Module. The call-ins route to designated administrative consoles and select SIP connected
telephones and can only be cleared from the system once answered. If a call-in is not answered within a preprogrammed time the call-in may reroute to other telephones and consoles, and announce over selected or all speakers and.

b. An option for Privacy call-in switches is supported. When the Privacy switch is activated it prevents administrative or classroom telephones from monitoring the specific classroom/location intercom speaker.

c. The ability to belong to one or more of a minimum of 100 independent zones for zone paging, program/music distribution zones and class change tone reception; this assignment is a programmable function, change able by time of day. Each IP Speaker Modules location shall be programmed in software to belong to any combination of software zones. Software/hardwired zones must be configured as part of an unlimited number of district wide groups for school district emergency announcements. These district announcements must be accessed via microphone, a web-browser or telephone.

d. IP Speaker Modules shall be designed to mount near ceiling and wall speakers and in the plenum space.

3. IP-addressable Zone Paging Module TCC2022:
   a. Zone paging module shall connect multiple speakers for district all page, all page, zone paging, bells, audio events and, emergency notification.
   b. Zone Paging Modules shall be rack and wall mountable.
   c. Zone Paging modules shall be able to belong to one or more of 50 independent zones for live paging, bells, pre-recorded audio and emergency notification.

4. IP Addressable Aux I/O Module TCC2033:
   a. Aux I/O Module shall have two input contacts and two output contacts.
   b. Input and output contacts are individually addressable.
   c. Aux I/O Module shall be wall and rack mountable.

   User can program relays to be activated manually, through an event/bell schedule and during emergency notification

D. IP Addressable Administrative Console TCC2044:
   1. A full color screen with 4 soft keys, 3 line select, volume control, push to talk, speakerphone mode and left/right and up/down scrolling.
   2. Audio paging access from any Console to any single intercom speaker, zone (group) of intercom/paging speakers, or all speakers/paging horns throughout the entire school.
   3. Programmable soft key access from any console on the system to initiate alarm signals within the school to all or select locations equipped with speakers. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative telephone shall have priority over all regular system functions.
   4. Programmable soft key access from any console to automatically broadcast page emergency instructions throughout an entire school when an alarm (e.g. lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.
   5. Ability to perform intercom to any single IP Addressable Speaker Module.
   6. Ability to display 3 call-ins at a time on the screen, with unlimited number of call-ins annunciating and the ability to scroll to view all call-ins.
   7. Ability to upgrade a call-in via soft key
   8. Ability to change which bell event schedule(s) are active on current day.
   9. Programmable soft key access from any console for activating relays, school wide
Ability to maintain, along with controller and other IP Modules system functions, including intercom, bells and paging in the event of district wide connection loss.

E. Audio Paging/Program Amplifiers Biamp MCA 8050
   1. Power amplifier(s) shall be provided to provide a minimum of 2 watts of power to all paging speakers, and 7 watts of power to all paging horns.
   2. The maximum load on the paging/program amplifiers shall be 80% of the rated maximum output of the amplifiers.

F. Normal/Emergency Call Switch – Rauland TCC2211PB Dual Level Call In Switch Cancel
   1. Normal/Emergency Call Switches indicated on the drawings shall provide the following functions and features:
      a. One (1) “Normal” call switch that shall activate a distinctive “NORM” level call from a single button activation. The button shall be clearly marked “NORM” and will route the call-in to any one or more Administrative Telephones or SIP interface to offsite telephones. This button may also be used as a “check-in” button during crisis situations.
      b. One (1) “Emergency” call switch that shall activate a distinctive “EMERGENCY” level call from a single button activation. The button shall be red in color and shall be clearly marked “EMERGENCY” and will route the call-in to any one or more Administrative Telephones or SIP interface for quick and easy response from an Administrative Telephone or off-site telephone.

G. SIP Gateway
   1. A SIP Gateway may be needed to differentiate existing classrooms from new classrooms equipped with IP speaker modules.
      a. The SIP Gateway shall provide a communications path to the existing intercom system.
      b. The SIP Gateway shall provide features and functions equivalent to the Patton SmartNode ™ 4520 FXO series.

H. Uninterruptible Power Supplies (UPS)
   1. UPS equipment provided for this system will include Power Conditioning to smooth current and voltage fluctuations.
   2. UPS equipment will be sized in accordance with the system manufacturer’s recommendations.
   3. Provide an individual UPS for EACH SYSTEM CONTROLLER (Gateway) furnished with the system.
   4. Provide additional UPS(s) for protection of all other equipment furnished with the system and housed in the equipment racks.
   5. All UPS equipment shall be rack mounted.

I. Equipment Racks
   1. All equipment racks shall provide 44 spaces (77”) minimum for mounted system equipment.
   2. All equipment racks shall be multi-rack format (“gangable”) style, bolted together, and open cavity.
   3. All equipment racks will be provided with lockable rear doors.
4. Equipment rack(s) shall be located in climate-controlled areas/rooms as shown on drawings.
5. All head-end, distribution, and source equipment, including data and power, shall be located in racks configured as approved by the Engineer.
6. Rack mounted equipment shall be accessible from front and rear.
7. All unused rack spaces will be covered with appropriate blank/vent panels.

J. Speakers:
1. Classroom Two-Way Speakers: Rauland BAFKIT1X2CS.
2. Ceiling Zone Speaker: Rauland BAFKIT1X2S.
4. Outside and Gym Horn: Rauland ACC1411.

2.3 IDENTIFICATION PRODUCTS
A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine conditions, with the Installer present, for compliance with requirements and other conditions affecting the performance of the School Communications and School Safety Network.
B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. General: Install system in accordance with NFPA 70 and other applicable codes. Install equipment in accordance with manufacturer's written instructions.
B. Furnish and install all material, devices, components and equipment for a complete operational system.
C. Impedance and Level Matching: Carefully match input and output impedance’s and signal levels at signal interfaces. Provide matching networks where required.
D. Control Circuit Wiring: Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
E. All housings are to be located as indicated.
F. The contractor shall provide necessary transient protection on the AC power feed, all copper station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.

G. Wiring within Enclosures: Provide adequate length of conductors. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.

H. Provide physical isolation from speaker-microphone, telephone, line-level wiring, and power wiring. Run in separate raceways, or where exposed or in same enclosure, provide 12 inch minimum separation between conductors to speaker-microphones, telephone wiring and adjacent parallel power. Provide physical separation as recommended by equipment manufacturer for other system conductors.

I. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

J. Weatherproofing: Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.

3.3 GROUNDING

A. Provide equipment grounding connections for Integrated Electronic Communications Network systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

B. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

C. Provide all necessary transient protection on the AC power feed and on all copper station lines leaving or entering the building. Note in system drawings, the type and location of these protection devices as well as all wiring information.

3.4 WIRING METHODS

A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 3/4".

3. Comply with requirements in Section 260111 "Cable Trays."

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.

### 3.5 INSTALLATION OF CABLES

**A.** Comply with NECA 1.

**B.** General Requirements for Cabling:
2. Comply with BICSI ITSIM, Ch. 6, and "Cable Termination Practices."
3. Terminate conductors in accordance with all manufacturer's recommendations.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, and "Pulling Cable." Monitor cable pull tensions.

**C.** UTP Cable Installation:
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

**D.** Group connecting hardware for cables into separate logical fields.

**E.** 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:
a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

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 (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.6 FIRESTOPPING

   A. Comply with requirements in Section 078413 "Penetration Firestopping."
   B. Comply with TIA-569-B, Annex A, "Firestopping."
   C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 IDENTIFICATION

   A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
      1. Administration Class: 2.
      2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels. See Evaluations for discussion about TIA/EIA standard as it applies to this Section.
   B. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
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/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner. Provide three (3) hard copies to owner. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect with rigid frame and clear plastic cover.

E. **Cable and Wire Identification:**
   1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. 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.
   3. 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.
   4. Meet with Logan City School District Telecommunications personnel and coordinate labeling requirements prior to installation.

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/EIA-606-A.

3.8 **FIELD QUALITY CONTROL**

A. Manufacturer's Field Services: Provide services of a duly factory authorized service representative for this project location to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.

B. Inspection: Make observations to verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Provide a list of final tap settings of paging speaker line matching transformers.

C. Testing: Rectify deficiencies indicated by tests and completely re-test work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
3.9 FINAL ACCEPTANCE TESTING

A. The Final Acceptance Testing shall be provided to the Owner or the Owners designated representative only. Final acceptance testing to any other trade or service provider for the project will not comply with the requirements of this section.

B. The contractor will provide a Final Acceptance Test record document signed by both the contractor and the Owner or designated Owner’s Representative establishing the “In Warranty” date. The warranty period will not commence until the Final Acceptance Test is completed.

C. Be prepared to verify the performance of any portion of the installation by demonstration, listening and viewing test, and instrumented measurements. Make additional adjustments within the scope of work and which are deemed necessary by the Owner because of the acceptance test.

3.10 COMMISSIONING

A. The contractor shall train the Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of the system. This training will be in accordance with the training as outlined in Section 1.6, paragraphs 3, 5 & 6 of these specifications. In addition to the Training Materials provided, the contractor will also furnish Operators Manuals and Users Guides at the time of this training.

B. Schedule training with Owner through the owners representative, with at least seven days advance notice.

3.11 OCCUPANCY ADJUSTMENTS

A. The contractor shall provide Occupancy Adjustments in accordance with Section 1.6, paragraph 9 of these specifications. A response scenario amenable to both the owner and the contractor will be established and followed for the first year of service.

3.12 CLEANING AND PROTECTION

A. Prior to final acceptance, the contractor shall vacuum and clean all system components and protect them from damage and deterioration. All blank spaces in equipment cabinets will be covered with blank panels. Top and side panels, and all cabinet doors will be installed. All general areas within and around all equipment rack/cabinets in the facility will be swept, vacuumed, and cleaned up. No cabinets will be left unlocked and all cabinet keys will be turned over to the owner or designated owner’s representative.

END OF SECTION 27 5123
SECTION 28 0721
DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Heat detectors.
6. CO Detectors.
10. Addressable interface device.
11. Digital alarm communicator transmitter.

1.3 DEFINITIONS

A. LED: Light-emitting diode.


C. VESDA: Very Early Smoke-Detection Apparatus.

1.4 SYSTEM DESCRIPTION

A. Noncoded, addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

B. System shall be UL-listed, and factory mutual-approved.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
1.6 SUBMITTALS

A. 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.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
8. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
   a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
   b. Retain one of first three subparagraphs below.
   c. Show field wiring required for HVAC unit shutdown on alarm.
   d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
   e. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
   f. Locate detectors according to manufacturer's written recommendations.
   g. Show air-sampling detector pipe routing.

D. Qualification Data: For qualified Installer.

E. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based.
and their installation requirements.

F. Field quality-control reports.

G. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7823 – Operation and Maintenance Data, include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
   A. Frequency of testing of installed components.
   B. Frequency of inspection of installed components.
   C. Requirements and recommendations related to results of maintenance.
   D. Manufacturer's user training manuals.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

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.

I. The disks containing fire alarm files shall be supplied to the owner. These disks shall include all information required to allow the owner to change the fire alarm program themselves. These computer disks shall contain a minimum of the following:

1. CAD drawing files of the building fire alarm map.
2. CAD drawing files of as-build fire alarm component and point-to-point connections.
3. General configuration programming.
5. Tutorial file on complete programming of the fire alarm system.

J. The system contractor/supplier shall provide a "Certificate of Compliance" to the Authority Having Jurisdiction in accordance with NFPA Pamphlet 72B (1986 Edition), Section 2-2.6, at the completion of operational acceptance tests, as required herein. This will be applicable to all types of fire alarm systems.

K. A complete set of CAD "as-built" drawings showing installed wiring, color coding, specific interconnections between all equipment, and internal wiring of equipment shall be delivered to the owner upon completion of the system installation.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project. Installation shall be by personnel certified by NICET as fire-alarm Level II technician.
B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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

1.8 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

1.9 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Heat Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.
8. Air-Sampling Fan: Quantity equal to one for every fan detectors, but not fewer than one unit of each type.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Installer / Telephone</th>
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<tbody>
<tr>
<td>Edwards Systems Technology</td>
<td>PST / (801) 649-6696</td>
</tr>
<tr>
<td></td>
<td>Wasatch Electric / (801) 487-4511</td>
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<tr>
<td></td>
<td>State Fire Sales and Service / (801) 288-2100</td>
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<tr>
<td>Simplex Grinnell</td>
<td>Simplex Grinnell / (801) 262-9406</td>
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<tr>
<td>Silent Knight</td>
<td>AAA Fire Safety and Alarm / (801) 544-7345</td>
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<td>Alarm Tech / (801) 568-6757</td>
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<td></td>
<td>AlphaCorp Security / (801) 977-8608</td>
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<tr>
<td></td>
<td>Certified Fire Protection / (801) 694-1215</td>
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<td>Peak Alarm / (801) 486-7321</td>
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<td></td>
<td>Professional Systems Technology / (801) 649-6696</td>
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<td></td>
<td>Fire Protection Services Corp. / (801) 363-9696</td>
</tr>
<tr>
<td></td>
<td>Firetrol Protection Systems / (801) 485-6900</td>
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2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

2. Heat detectors.
3. Smoke detectors.
4. Air-Sampling Smoke detectors.
5. Duct smoke detectors.
6. CO Detectors.
7. Verified automatic alarm operation of smoke detectors.
8. Automatic sprinkler system water flow.
9. Heat detectors in elevator shaft and pit.
10. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Recall elevators to primary or alternate recall floors.
8. Record events in the system memory.
9. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Elevator shunt-trip supervision.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.
10. Alert and Action signals of air-sampling detector system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   A. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   B. Include a real-time clock for time annotation of events on the event recorder and printer.
2. Addressable initiation devices that communicate device identity and status.
   A. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
   B. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, two (2) lines of forty (40) characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   A. Initiating Device Circuits: Style D.
   B. Notification Appliance Circuits: Style Z.
   D. Install no more than 100 addressable devices on each signaling line circuit.


D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.


F. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.
   A. Elevator lobby detectors except the lobby detector on the designated floor.
   B. Smoke detector in elevator machine room.
   C. Smoke detectors in elevator hoist way.
2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
   A. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out the final adjusted values on system printer.

I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

J. 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.
K. 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.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2. Capacity: Size for all finished and unfinished spaces within building plus twenty-five (25) percent ampere-hour capacity.

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. 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-operated switch.
3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
5. Provide addressable monitor module for each manual fire-alarm box and locate in outlet box.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Detectors shall be two-wire type.
2. 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.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
5. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
   A. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
B. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).

C. Provide 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.).

3. This is the default detector type to be used on the product, unless specifically indicated otherwise.

C. 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.

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.


2.6 PROJECTED BEAM SMOKE DETECTORS

A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.

B. Detector Address: Accessible from fire-alarm control unit and able to identify the detector's location within the system and its sensitivity setting.

C. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   1. Primary status.
   2. Device type.
   3. Present average value.
   4. Present sensitivity selected.
   5. Sensor range (normal, dirty, etc.).

2.7 HEAT DETECTORS
A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
   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 (88 deg C).
   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.

D. Continuous Linear Heat-Detector System:
   1. Detector Cable: Rated detection temperature 155 deg F (68 deg C). NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short-circuit wires at the location of elevated temperature.
   2. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
   3. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
   4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 CARBON MONOXIDE DETECTORS

A. General Requirements for Carbon Monoxide Detectors: Comply with UL 268 and UL 2075 listed.

B. Carbon Monoxide Detector, Combination Type: Actuated by either by fire or carbon monoxide.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 AIR-SAMPLING SMOKE DETECTOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Fenway Protection Systems; A UTC Fire & Security Company.
   2. Fike Corporation.
   3. Xtralis Pty Ltd.

B. General Description:
   1. Air-sampling smoke detector shall be laser based using a piping system and a fan to transport the particles of combustion to the detector.
2. Provide two levels of alarm from each zone covered by the detector and two supervisory levels of alarm from each detector.
3. The air being sampled shall pass through filters to remove dust particulates greater than 20 microns before entering the detection chamber.
4. Detectors shall have the capability via RS 485 to connect up to 100 detectors in a network.
5. Detectors shall communicate with the fire-alarm control unit via addressable, monitored dry contact closures, RS 485, and interface modules. Provide a minimum of six relays, individually programmable remotely for any function.
6. Pipe airflow balancing calculations shall be performed using approved calculation software.

C. Detector:
1. Detector, Filter, Aspirator, and Relays: Housed in a mounting box and arranged in such a way that air is drawn from the detection area and a sample passed through the dual-stage filter and detector by the aspirator.
2. Obscuration Sensitivity Range: 0.005 - 6 percent obs/ft.
3. Four independent, field-programmable, smoke-alarm thresholds per sensor pipe and a programmable scan time delay. The threshold set points shall be programmable.
   a) The four alarm thresholds may be used as follows:
      1) Alarm Level 1 (Alert): Activate a visual and an audible supervisory alarm.
      2) Alarm Level 2 (Action): Activate shutdown of electrical/HVAC equipment and activate a visual and an audible supervisory alarm.
      3) Alarm Level 3 (Fire 1): Activate building alarm systems and initiate call to fire response unit.
      4) Alarm Level 4 (Fire 2): Activate suppression system or other countermeasures.
   b) Final Detection System Settings: Approved by Owner.
   c) Initial Detection Alarm Settings:
      1) Alarm Level 1 (Alert): 0.08 percent obs/ft.
      2) Alarm Level 2 (Action): 1.0 percent obs/ft.
      3) Alarm Level 3 (Fire 1): 2.0 percent obs/ft.
      4) Alarm Level 4 (Fire 2): 4.0 percent obs/ft.
4. Power Supply:
   a) Regulated 24-V dc, monitored by the fire-alarm control unit, with battery backup.
   b) Battery backup shall provide 24 hours’ standby, followed by 30 minutes at maximum connected load.
5. Detector shall also transmit the following faults:
   a) Detector.
   b) Airflow.
   c) Filter.
   d) System.
   e) Zone.
   f) Network.
   g) Power.
6. Provide four in-line sample pipe inlets that shall contain a flow sensor for each pipe inlet. The detector shall be capable of identifying the pipe from which smoke was detected.
7. Aspirator: Air pump capable of allowing for multiple sampling pipe runs up to 650 feet (200 m) in total, (four pipe runs per detector) with a
transport time of less than 120 seconds from the farthest sample port.

8. **Air-Sampling Flow Rates Outside Manufacturer's Specified Range:**
   Result in a trouble alarm.

9. **Provide software-programmable relays rated at 2 A at 30-V dc for alarm and fault conditions.**

10. **Provide built-in event and smoke logging; store smoke levels, alarm conditions, operator actions, and faults with date and time of each event. Each detector (zone) shall be capable of storing up to 18,000 events.**

11. **Urgent and Minor Faults. Minor faults shall be designated as trouble alarms. Urgent faults, which indicate the unit may not be able to detect smoke, shall be designated as supervisory alarms.**

D. **Displays:**
   1. Include display module within each detector.
   2. Each display shall provide the following features at a minimum:
      a) A bar-graph display.
      b) Four independent, high-intensity alarm indicators (Alert, Action, Fire 1, and Fire 2), corresponding to the four alarm thresholds of the indicated sector.
      c) Alarm threshold indicators for Alert, Action, and Fire 1.
      d) LED indication that the first alarm sector is established.
      e) Detector fault and airflow fault indicators.
      f) LED indicators shall be provided for faults originating in the particular zone (Zone Fault), faults produced by the overall smoke-detection system, and faults resulting from network wiring errors (Network Fault).
      g) Minor and urgent LED fault indicators.

E. **Sampling Tubes:**
   1. Smooth bore with a nominal 1-inch (25-mm) OD and a 7/8-inch (21-mm) ID. Sampling pipe with between 5/8- and 1-inch (15- and 25-mm) ID can be used in specifically approved locations when recommended by manufacturer.
   3. Joints in the sampling pipe shall be airtight. Use solvent cement approved by the pipe manufacturer on all joints except at entry to the detector.
   4. Identify piping with labels reading: "Aspirating Smoke Detector Pipe - Do Not Paint or Disturb" along its entire length at regular intervals according to NFPA 72.
   5. Support pipes at not more than 60-inch (1520-mm) centers.
   6. Fit end of each trunk or branch pipe with an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

F. **Sampling Holes:**
   1. Sampling holes of 5/64 inch (2 mm), or other sized holes per manufacturer's written instructions, shall be separated by not more than the maximum distance allowable for conventional smoke detectors. Intervals may vary according to calculations.
   2. Follow manufacturer's written recommendations to determine the number and spacing of sampling points and the distance from sampling points to ceiling or roof structure and to forced ventilation systems.
   3. Each sampling point shall be identified by an applied decal.

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2.10 **NOTIFICATION APPLIANCES**

Ellis Elementary School  28 0721 - 12  DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM
A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:
   A. 15/30/75/110 cd, as indicated in drawings, or
   B. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, [red] [white].

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

B. Material and Finish: Match door hardware.

2.12 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: 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.

2.13 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
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. Zone of the supervisory signal.
3. Zone of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.15 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

2.16 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 – EXECUTION

3.1 EQUIPMENT INSTALLATION
A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Power for the panel, battery charger, or any other device which affects the operation of the system shall be controlled through a single circuit breaker labeled, "Fire Alarm System – Do Not Turn Off." Connect to engine generator-supported emergency circuit where available.

C. Equipment Mounting: Install wall-mounted fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   2. Locate fire alarm control unit as directed by the authority having jurisdiction.

D. Raceway: Install fire alarm conductors in raceway. Fire alarm system conductors from different zones may be combined in common conduit. Make certain that raceway and wire quantity, size, and type are suitable for equipment supplied and is within NEC standards. No wiring other than that directly associated with the fire alarm and detection systems shall be permitted inside the fire alarm conduits. All conduit, mounting boxes, junction boxes, panels, detectors, alarm devices, etc., shall be mounted and fastened with appropriate fittings to insure positive grounding throughout the system.

E. Loop wires through each device in zone for proper supervision. Tee-taps are not permitted. Wiring splices are to be avoided to the maximum extent possible; if needed, they must be made only in junction boxes. Transposing or changing color-coding of the wires shall not be permitted.

F. Provide dust protection for installed and existing (if any) smoke detectors until finish work is completed and building is ready for occupancy.

G. Protect conductors from cuts, abrasion, and other damage during construction.

H. Minimum conductor size shall be 14 AWG, unless otherwise specified. Shielded and/or stranded conductors shall be provided where recommended by the manufacturer.

I. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
   1. Connect new equipment to existing control panel in existing part of the building.
   2. Connect new equipment to existing monitoring equipment at the supervising station.
   3. Expand, modify, and supplement existing control equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

J. Smoke- or Heat-Detector Spacing:
   3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
   4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
   5. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
   6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
K. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

L. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

M. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

N. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

O. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

P. Audible Alarm-Indicating Devices: Install at +80 inches (2032 mm) above finished floor, but not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

Q. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn at +80 inches (2032 mm) above finished floor, but at least 6 inches (150 mm) below the ceiling.

R. Device Location-Indicating Lights: Locate in public space near the device they monitor.

S. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

T. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

U. Do not install manual fire alarm boxes close to light switches.

V. Manual alarm initiating stations shall be provided at all required building exits, boiler rooms, kitchens, and main administrative offices, and elsewhere to provide a maximum 200’ travel distance to a pull station from any point in the building.

W. Post copy of wire identification list inside fire alarm panel door and other area accessible to fire alarm service personnel.

X. The control and other panels shall be mounted with sufficient clearance for observation and testing.

Y. All fire alarm junction boxes shall be identified with zone number and red paint for easy identification.

Z. Mount remote multi-signaling accessory for non-system duct smoke detector in a readily accessible location and wire complete.

3.2 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system.
being controlled.

1. Smoke dampers in air ducts of designated air-conditioning duct systems.
2. Alarm-initiating connection to elevator recall system and components.
4. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
5. Supervisory connections at elevator shunt trip breaker.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals per owner’s requirements.
B. Install framed instructions in a location visible from fire-alarm control unit.
C. All fire detection devices shall be marked in nominal ½” high letters with the zone and device number (for example: a mark reading, “1-20,” indicated Zone 1, Device Number 20).
D. Building Fire Map:

1. A building fire alarm map shall be supplied to the owner, indicating the exact location and address of all individual devices. Install the building map adjacent to the fire alarm panel. Provide a high-quality plastic sign (map holder) with two layers. The back layer shall be painted black. The front layer shall have a clear center for viewing the CAD fire alarm drawing. The edges of the sign shall be colored to match the building interior. The building map shall indicate zoning by the use of five different colors, minimum.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Engineer and authorities having jurisdiction.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
D. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   A. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
   B. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the
"Inspection, Testing and Maintenance" Chapter in NFPA 72.
3.  Test audible appliances for the public operating mode according to manufacturer's written instructions and Authority Having Jurisdiction. 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 and Authority Having Jurisdiction.
5.  Test visible appliances for the public operating mode according to manufacturer's written instructions and Authority Having Jurisdiction.

E.  Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F.  Fire-alarm system will be considered defective if it does not pass tests and inspections.

G.  Prepare test and inspection reports.

H.  Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I.  Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6  DEMONSTRATION

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

END OF SECTION 28 0721
PART 1 - GENERAL

1.01 SYSTEM DESCRIPTION

A. The Access Control System shall be fully integrated and installed as a complete package by the Access/Security Control Contractor. The SMS shall be able to provide for and integrate the following subsystems:

1. Integrated Access Control.
2. Alarm Monitoring.
3. Associated Access Control and Alarm Equipment Control.
4. Multiple Language Operation
5. Access Initiated and Event Initiated Control
6. Integrated Video Badging System
7. Workstation and associated equipment as required.

B. The SMS shall be based upon a distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on a true peer-to-peer, token passing Local Area Network (LAN). The SMS shall be capable of monitoring, recording, and displaying card access activity and supervised alarm inputs/outputs on a continuous, real time basis. Each installation shall comply with local, state, and federal code requirements as applicable.

C. The SMS shall be capable of providing access control and alarm monitoring capabilities for large and small facilities. The system shall be user friendly, providing a user interface that allows for training of non-technical personnel to effectively operate and administer the system.

D. The SMS shall be designed to provide a centralized location with the ability to monitor, control, view, and communicate from a secure location within a facility.

E. System expansion capability: Minimum 25% over specified requirements.

1.02 SYSTEM CAPABILITIES

A. The following functional capabilities are considered essential for the Security Management System described in this specification:

1. Integrated Access Control
2. Intrusion Detection
3. Door Control
4. First Key Auto Unlock
5. Anti-Passback control
6. Alarm Assessment (Instructions)
7. Database Security And Encryption
8. Maps Displaying Alarm Points
9. If/Then/and/or/not functions
10. Time Scheduled Events
11. Access Control initiated events
12. Calculations
13. Windows Based, Mouse oriented operations
14. Alarm processing from remote locations
15. Processing of Access Control functions for remote locations
16. Integrated Video Badging and user configurable, automatic image verification
17. Ability to Import and Export cardholder data
18. Comprehensive User Definable Reports for transactions, alarms, messages and events
19. Comprehensive User Definable Database Reports
20. Comprehensive User Definable Archiving
21. Visitor Management
22. Two Man Rule
23. Support for OPC, DDE and ODBC technologies
24. Ability to be WEB enabled

1.03 RELATED WORK

A. Door hardware. Not specifically covered under this specification.

B. Wiring / Cable Specifications. NOTE: Coaxial wiring for data communications is not acceptable.
   1. Wiring requirements are indicated on the drawings. All wiring shall in strict accordance with all manufacturers’ recommendations.
   2. All other cable is to meet the following requirements as outlined below:
      a. UL Listed
      b. NEC approved
      c. Plenum rated where required
      d. All cabling shall be shielded unless specified otherwise by a card access manufacturer.
      e. As a minimum, standard 18 AWG cable shall be installed unless in direct conflict with manufacturers specifications
      f. All cabling used in the implementation of systems integration shall be in accordance with the recommendations of the manufacturer.
   3. Provide specialist personnel for the complete wiring installation. Provide cables, conduits, cable tray and ancillary equipment necessary to complete the installation. Refer to Division 26 for additional requirements.
   4. The installation contractor must be licensed in the State of Utah as a Burglar Alarm Company. The installation contractor must be an authorized dealer of the access control system. The installation contractor must be a licensed Electrical Contractor in the State of Utah.

C. Grounding
   1. Take particular attention to the grounding of equipment cases and shielded cables to eliminate noise interference and avoid electrical loops. Provide shielded cable for all communications cabling. Correctly terminate shields at ground bars and connect to the main building ground or as specified by the manufacturer.
      a. Insulate all incoming or outgoing shielded cables from control cabinet casings.
      b. Provide suitable terminals, where grounding of cable shields is required.
      c. Make provision of a through connection of cable shields for through connected communications cables.

D. Programmers
   1. Experienced in the field of security services to suit the application. Carry out the complete design and programming of the installation in the local office of the system
E. System Support

1. System support: Provide a guarantee of system support for a minimum period of six years after final completion, including provision for technical support, hardware, and spare parts. Demonstrate that the manufacturer’s previous systems have not been made obsolete and that the manufacturer is committed to total and complete backward compatibility.

1.04 SUBMITTALS

A. Provide a submittal for approval prior to commencement of installation and training to include:

1. English language description of system operation.
2. Logical flow charts.
3. Building floor plans indicating all secured portals and intrusion devices.
4. Input/output point schedules.
5. A copy of the database put into logical groups that represent how information will be displayed to the user.
6. All graphics.
7. Floor plans showing location of all controllers and sensors.
8. Co-ordination drawings showing interface terminal numbers and cross-referenced wire numbers for all connections between the SMS and other equipment.
9. Details of all readers, control devices, and sensors.
10. Full details of each control station including equipment and wiring diagrams and terminal layouts.
11. Fully detailed wiring diagrams for the entire security control, monitoring and electrical cabling installation.

1.05 MATERIALS

A. Unless indicated otherwise, furnish and install at locations shown, the specified equipment to provide a completely operational Access Control/Security Management system. The following list of main items of the installation shall not be considered to be all-inclusive:

1. Door hardware and accessories
2. Readers
3. Monitors
4. Distributed Control Units (DCU’s) – Main Controller
5. Door Processing Units (DPU’s) – Main Door Controllers
6. Printers
7. Alarm relays
8. Miscellaneous cable, wire, associated connectors, and hardware
9. Power supplies
10. All materials and equipment shall be standard, regularly manufactured equipment.
11. All systems and components shall be thoroughly tested and proven in actual field use.
12. All system main control components shall be from one manufacturer.

1.06 Quality Assurance

A. System manufactures shall have implemented a Quality System that complies with the ISO9001 model. Factory owned System Integrators shall be able to exhibit a commitment to
gaining ISO9002 accreditation or shall have an existing accreditation in place. A factory owned office that is also ISO 9001/ISO 9002 certified or an authorized distributor of the manufacturer shall install the SMS equipment. Any other installers will not be acceptable bidders for this project.

B. Evidence of the Quality System Audits may be requested.

1.07 WARRANTY PERIOD

A. General: Provide maintenance of the system during the warranty period with the following minimum provisions:

1. Notify building owner's representative prior to performing any maintenance work.
2. The designated representative to monitor and report on equipment performance and service history, and to be a liaison with the building owner.
3. Conditions: The warranty shall cover any defects in materials and workmanship including installation and programming which shall be found during the term. This shall include any deficiencies in installation standards vis-à-vis the specifications.
4. Response: The contractor shall respond to calls for warranty service within eight working hours. Emergency service shall be obtainable within four hours of notification by the Owner. Emergency service shall be obtainable on a 24 hours basis, seven days per week.
5. Qualifications: The contractor shall utilize factory-trained technicians located within 100 miles of the job site.

B. Extended service agreement:

1. Provide a renewable annual maintenance agreement. The agreement shall provide for periodic inspections and maintenance of repair items. The agreement shall at a minimum provide for all of the terms and conditions of the warranty.

1.08 OPERATION AND MAINTENANCE DATA

A. Operation Manuals: The contractor shall deliver six composite “Systems Operation and Maintenance” manuals in three-ring binder form or bound handbook form, sized to hold the material below. Each manual shall contain, but not be limited to:

1. A Statement of Guarantee including date of termination and the name and phone number of the person to be called in the event of equipment failure.
2. A set of operational procedures for the overall system that includes all required customer activities that allow for customer operation of all system capabilities. This procedure shall fully address all customer-established system operating objectives.
3. Individual factory-issued manuals, containing all technical information on each piece of equipment installed. In the event such manuals cannot be obtained from a manufacturer, it shall be the responsibility of the contractor to compile and include them. Advertising brochures or operational instructions shall not be used in lieu of the required technical manuals and information. All manuals shall be printed to ensure their permanence. No “blue line” type of reproduction is acceptable.
4. Provide six sets of manuals to include:
   a. Updated functional specification.
   b. Specification sheets and technical brochures on all equipment.
   c. Fault finding literature.
   d. Listings and description of application programs.
   e. Programmer's manual.
   f. Operator's manual including schedules of alarms, parameters, status, analog indicators, circuit diagrams, etc.
g. Drawings.
h. Commissioning data.

B. Maintenance Pricing: Provide a SEPARATE, fixed price for comprehensive maintenance of the complete SMS system from date of completion of the Warranty Period for the required period.

C. The Owner has the option of accepting or rejecting the proposal. The proposal will be used to evaluate the successful bidder. The proposal provides:

1. Preventative or routine maintenance as required after the Warranty Period.
2. All labor and materials for repair or replacement of defective equipment as required after Warranty Period
3. 24 hour, seven days a week breakdown service with a maximum of 24 hours response time.
4. A designated representative to monitor and report on equipment performance and service history and to be a liaison with the building owner.
5. Continuity of service personnel.
6. Provision and installation of software revisions.

1.09 OWNER’S TRAINING

A. The contractor shall supply personnel to train key customer personnel in the operation and maintenance of the installed system. The training program shall be designed to provide a comprehensive understanding and basic level of competence with the system. It shall be sufficiently detailed to allow customer personnel to operate the system independent of any outside assistance.

B. On-line context-sensitive HELP screens shall be incorporated into the system to further facilitate training and operation.

C. The training plan shall include detailed session outlines and related reference materials. The customer personnel shall be able to utilize these materials in the subsequent training of their co-workers.

D. Training time shall not be less than a total of 16 hours, and shall consist of:

1. 8 hours during normal day shift periods for system operators. Specific schedules shall be established at the convenience of the customer.
2. 8 hours of system training shall be provided to customer supervisory personnel so that they are familiar with system operation.
3. The specified training schedule shall be coordinated with the customer and will follow the training outline submitted by the contractor as part of the submittal process.

1.10 EXTRA MATERIALS

A. Based upon the contractor’s and the manufacturer’s experience with the equipment’s performance history, the contractor shall submit a final spares list for all functions for this system. This list shall be based upon a philosophy of maintaining a central system operation with a simple remove/replace capability. The final spares list shall be developed as a result of a joint customer/contractor review of the recommended list during the installation phase. Submit this final recommended spare list for approval prior to system completion, so that spares are available upon activation.

B. As a minimum, provide:
1. Adequate response time
2. Adequate spare parts, to complete repairs within 48 hours of arrival at the job site.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Access Control System
   1. Basis of Design:
      ProdataKey
      10702 S 300 W.
      Suite 105
      South Jordan, Utah 84095
      Local Phone: (801)317-8802
      Toll Free Phone: (800) 218-0283
      Fax: (801) 317-880
      Website: www.prodatakey.com

2.2 ACCESS CONTROL SYSTEM REQUIREMENTS

A. Provide new access control system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.

B. Access Control Points:
   1. Refer to Architectural Door Hardware Specification Section 08 71 00 for the door hardware listing for each door within building, including the type of egress hardware used and a description of the operation of the door.
   2. Refer to the Architectural DOOR SCHEDULE for a complete list of doors on the project and those with specific hardware requirements for control.
   3. See Electrical Drawings for specific components:
      a. Peripherals on Secure Side:
         i. Reader/Keypad: Proximity Reader
      b. Locking Device: Electric strike or magnetic lock, provided by others to be coordinated with Door Hardware Consultant.
         i. Configuration: Fail-safe, as noted within Door Hardware Specifications.
      c. Interface Requirements:
         i. Provide interface with fire alarm system to release door lock upon activation of fire alarm system.

C. Interface with Other Systems:
   1. Provide products compatible with other systems requiring interface with access control system.
   2. Interface with electrically operated door hardware as specified in Section 08 71 00.
      a. Capable of locking/unlocking/releasing controlled doors.
      b. Capable of receiving input from integral door hardware switches.
   3. Interface with fire alarm system as specified in Section 28 31 00.

D. Provide products listed, classified, and labelled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
   1. Access Control Units and Readers: Listed and labelled as complying with UL 294.

2.3 ACCESS CONTROL UNITS AND SOFTWARE

A. Provide access control units and associated software compatible with readers to
be connected.
1. System to be able to control the necessary quantity of doors through the interconnection of Eight Door and Single Door Controller cabinets. Connections can be made through wireless or network communications.
2. Wireless based controllers shall be provided using iMac (wireless mesh access control) technology with up to 1,000 devices per site.
3. Network based controllers shall be provided through network communications using Category 6 cabling from device to device as needed.
4. System to provide unlimited card holders along with event storage, battery back-up and automatic offsite data back-up of not less than 180 days.
5. System to allow for complete configuration and management through pdk.io SaaS based management service via two factor authentication using Internet connected mobile devices and other compatible Internet connected web browsers.

B. Computers:
1. Workstation Computers: Unless otherwise indicated, workstation computer hardware and associated peripherals not furnished by access control system manufacturer to be provided by others, meeting access control system equipment manufacturer's recommended requirements.

C. Badging Peripherals: Unless otherwise indicated, badging peripherals not furnished by access control system manufacturer to be provided by others.

D. Software:
1. Unless otherwise indicated, provide all software and licenses required for fully operational system.
2. Pdk.io cloud software for Cloud Node configuration, management and control. Minimum functionality to include but not limited to:
   a. 180-day cloud backup
   b. Real-time software updates
   c. Custom reporting
   d. Wireless mobile site surveys
   e. Email and txt supervision and alerting
   f. True site partitioning
   g. Custom rules engine
   h. Elevator control

2.4 EIGHT DOOR CONTROLLER – PART NUMBER PM-07-EIO-W,E

A. Use the Eight Door Controller for eight individual doors. Add the Eight Door Expansion kit to control sixteen doors out of one 12x12 security cabinet.

B. Specifications:
1. Connections: Power Input, Normally Open, Normally Closed, Common, Reader Port, Request to Exit and Door Position Sensor for 8 individual ports. 2 x auxiliary PCB terminals to control 2 x Aux relays
2. Com-Modules: w i m a c Wireless and Network (Ethernet)
3. Connectors: Removable PCB terminals with screw down wire crimps
4. Relays: 10 Industrial grade form C relays (8 Door / 2 Aux)
5. Onboard Memory: Store up to 10 E-Cards

2.5 CARD READERS – PART NUMBER PM-08-RDR-M,G,KP,MR,GR

A. Wiegand Output Proximity Readers. 125KHz EM and 125KHz HID formats are compatible with these readers. These readers have the ability to read a HID format between Wiegand ranges of 26 bits - 37 bits. The default EM bit range is set to Wiegand 26 bits.
1. Specifications: Operating Voltage: 12 V D C
2. Frequency: 125K Hz
3. Card Type: EM card and HID card format
4. Reading Distance: 1 3/8 to 3 1/8”
5. Output: HID Wiegand 26 - 37, EM Wiegand 26

B. System shall be capable of working with HID Proximity Card Readers.

2.6 DOOR POSITION SWITCHES:
A. Magnetic Contacts: Provided by Door Hardware Consultant. Coordinate integration with Door Hardware specifications.

2.7 ELECTRIC STRIKES
A. Electric Strikes: Provided by Door Hardware Consultant. Coordinate integration with Door Hardware specifications.
B. Power to electric strikes to be furnished by the Electrical Contractor.

2.8 ELECTRO-MAGNETIC LOCKS:
A. Provided by Door Hardware Consultant. Coordinate integration with Door Hardware specifications.

PART 3- EXECUTION

3.01 INSTALLATION
A. The installation contractor must be an authorized dealer of the access control system. The installation contractor must be a licensed Electrical Contractor in the State of Utah.
B. Install and connect all devices in locations as shown on the drawings in accordance with standard industry practice.
C. Install and adequately support fixed wiring throughout the installation. For cabling routes not specified in detail, submit a proposed route layout. Install bulk cable runs from switchboards to SMS panels in metal ducts.
D. Handling cables: Handle cables to avoid damage to insulation and sheathing. Report any damage and replace or repair damaged cable as directed.
E. Straight-through joints: Unless unavoidable due to length or difficult installation conditions, run cables for their entire route length without intermediate straight-through joints. Where straight-through joints are used contain within a junction box arranged so that they are accessible after installation.
F. Tagging: Identify all cables at each end and at crowded intermediate points by means of stamped, non-ferrous tags, clipped around each cable.
G. Segregation: Physically segregate data cabling from power and SMS input/out cabling and mains cabling from all other cabling.
H. Panels
1. Install panels and controllers within a dedicated metal enclosure.
2. Documentation: Provide plastic fade-free points list in a pocket. Include terminal numbers, point addresses and short and long descriptions.


3.02 PRECONSTRUCTION MEETING:

A. Attend a Preconstruction Meeting with the Logan City School District to review installation standards prior to doing any work.

3.03 WIRING METHODS

A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile accessible ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 1".
3. Comply with requirements in Section 260111 "Cable Trays."

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.

3.04 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.

7. 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.

8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

9. In the communications equipment room, install a 10-foot-long service loop on each end of cable.

10. 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 (12 mm) from the point of termination to maintain cable geometry.

D. Group connecting hardware for cables into separate logical fields.

E. 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:
   
a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).

b. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

b. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

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 (76 mm).

b. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.05 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.06 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with J-STD-607-A.
C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) 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 TRANSMISSION SYSTEMS

A. The SMS shall utilize the above LAN architecture to allow all of the Control Units to share data as well as to globalize alarms. The Controller LAN shall be based upon a peer-to-peer, token passing technique with a data speed of not less than 19.2 Kb. Systems which require a "master" communications controller or network manager for the Controller LAN are not acceptable.
B. To ensure high throughput, data transmission shall use "packetized" communication techniques, such that dozens of "messages" are contained in each "packet".
C. The "turnaround time" for a global point to be received by any node, including operator stations, shall be less than three seconds.
D. Fiber Optic Pathways: If required, fiber optic media shall be used between buildings for the Controller LANs. Wherever the optical fiber enters or leaves the building, provide a fiber to hard copper interface device. The FOI shall regenerate data prior to transmitting this data to either the fiber or hard copper channels, so as not to result in the degradation of signal and to minimize the accumulation of errors between multiple FOIs. The FOI shall include "jabber" protection, such that continuous data from a defective component will not destroy communications on the LAN. Provide visual indication of receiving and transmitting data activity on the hardwired drop. Provide visual indication of data transmission on the fiber media, jabber presence on fiber and hard copper channels, and
bad signal quality on the hard copper channel.

3.08 COMMUNICATIONS

A. Utilize an established LAN or other communication standard to link all SMS equipment.

B. Technique: Token Passing network for Controller LAN, Polled for Small Point & Application Specific Controllers.

C. Configuration: A break in the communication path of the Controller LAN shall be announced as an alarm and shall automatically initiate a Controller LAN reconfiguration such that the resulting sections of the Controller LAN continue to function as separate LANs. No loss of control shall result from such a break in the Controller LAN.

D. Data corruption: Check all data and retransmit if corruption has occurred. Provide adequate buffering to ensure that important data is not lost.

E. Commercial LAN: Workstations on the Controller LAN may also reside on a higher tier "commercial" LAN. This "commercial" LAN shall be based upon Ethernet, and comply with IEEE 802.3 standards. Where a "commercial" LAN is implemented, it shall be possible to connect multiple Controller LANs together, with global data sharing across this commercial LAN.

F. An operator at a workstation on the "commercial" LAN may connect to any other workstation on the "commercial" LAN as if the operator were sitting at the other workstation.

G. Alarms and special event notices shall be routed to different workstations on the "commercial" LAN based upon time of day, and day of the week.

H. Operator password assignment shall be available on both a system-wide basis and a workstation by workstation basis.

3.09 TESTING AND COMMISSIONING

A. GENERAL

1. The contractor shall perform all tests submitted in the “Test Procedure” section as outlined in the specification.
2. Provide a program for the testing and commissioning procedure. Use a qualified representative of the SMS supplier to co-ordinate testing and present at all tests and training courses and remain on-site until the SMS is fully operational.

B. FACTORY TESTING

1. Procedure: Submit procedure for factory test at least two weeks prior to the test.
2. Demonstration: Demonstrate each control loop including all calculations and global functions. Simulate analog values with potentiometers if required. Allow for attendance by three persons nominated by the Owner.
3. After test: Submit summary of results and necessary modifications.

C. SITE TESTING AND COMMISSIONING

1. Carry out the following:
a. Testing and commissioning of all SMS panels separately before connecting to the network.
b. Attendance at the testing of all equipment that interfaces to the SMS and confirmation of the operation of such equipment from the SMS interface terminals.
c. Testing and calibration checks of all installed controllers, actuators and sensors by actual operation of the devices.
d. Testing of all field wiring from terminals to field interface terminal strips.
e. Testing and commissioning of all power supplies and batteries.
f. Verification of communication to remote systems.
g. Testing of the operation of each control point from the operator's workstation (if supplied) and verification of the status of all points and alarm functions on graphic displays.

2. Demonstrate the following:
   a. Operation of each control loop.
   b. Calibration of sensors.
   c. Globally transferred information such as alarms.
   d. Detection and action of all alarm conditions.
   e. Communications with PC workstations.
   f. Time schedules and after-hours operation.
   g. Mapping of system points to operator's workstation(s).
   h. Operator's workstation software.
   i. Power fail re-start.
   j. Essential power mode operation.
   k. Fire mode of operation.
   l. Telecommunication facilities.

D. FINAL ACCEPTANCE TEST:

1. After the testing report and as built drawings have been approved by the customer's representative, the completed system shall be tested in the presence of the customer's representative.

2. Acceptance of the system shall require a demonstration of the stability of the system. Should major equipment failure occur, the contractor shall replace or repair component(s). This test shall not start until the customer has obtained 30 days beneficial use of the system.

3.10 NOTICE OF COMPLETION

A. When the final acceptance test described above has been satisfactorily completed, the contractor shall issue a letter of completion to the customer indicating the date of such completion. The notice of completion shall be recorded by the contractor upon receipt of the customer completion letter. This date of record shall be the start of the one-year guarantee period.

END OF SECTION 28 0730
SECTION 28 1600
INTRUSION DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes intrusion detection with communication links to perform monitoring, alarm, and control functions.

1.2 DEFINITIONS

A. Control Unit: System component that monitors inputs and controls outputs through various circuits.

B. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.

C. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.

D. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes.

E. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

1. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.

2. UPS: Sizing calculations.

3. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building.

4. Master Control-Unit Console Layout: Show required artwork and device identification.

5. Device Address List: Coordinate with final system programming.

6. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.

7. Details of surge-protection devices and their installation.

8. Sensor detection patterns and adjustment ranges.
C. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

D. Samples: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.

2. Fuses: Three of each kind and size.

3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.

2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

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. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.

E. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.

F. Comply with NFPA 70.
1.8 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Altitude: Sea level to 5000 feet (1524 m).
2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Interior, Controlled Environment: System components, except master control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Description: Hard-wired, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.

C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.

D. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.

E. Operator Commands:

1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
5. Protected Zone Test: Initiate operational test of a specific protected zone.
7. Print reports.

F. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

G. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:

1. Switch selected lights.
2. Shift elevator control to a different mode.
3. Open a signal path between certain intercommunication stations.
4. Shift sound system to "listening mode" and open a signal path to certain system speakers.
5. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.

H. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

I. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.

J. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

K. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.

L. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

M. A dedicated hard-wired zone shall be provided for each system device.
2.2 SYSTEM COMPONENT REQUIREMENTS

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.

2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.

B. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.

C. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.

D. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.

E. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.

F. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.

G. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.

H. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.

B. Interior Electronics: NEMA 250, Type 12.

C. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 MASTER CONTROL PANEL

A. Manufacturers: Provide DSC MAXSYS Control panel only. No substitutions allowed.
B. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data. Provide DSC 4501 Key Pads. No substitutions.

2.5 PIR SENSORS

A. Manufacturers:

4. Under sensor housing cover.

2.6 DURRESS SWITCHES

A. Manufacturers:

1. Provide Honeywell 270R.

2.7 BATTERIES

A. Manufacturers:

1. Yuasa brand with minimum standby capacity of 24 hours.

PART 3 - EXECUTION

3.1 SYSTEM INSTALLATION

A. Comply with UL 681 and NFPA 731.

B. Provide installation and connections for a complete system in accordance with all manufacturer's written instructions.

C. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3.2 PRECONSTRUCTION MEETING:
A. Attend a Preconstruction Meeting with the Logan School District to review installation standards prior to doing any work.

3.3 WIRING METHODS
A. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, and accessible lay-in tile accessible ceilings. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed in accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 260110 "Conduit Raceways." Minimum raceway size is 3/4".
3. Comply with requirements in Section 260111 "Cable Trays."

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.

3.4 INSTALLATION OF CABLES
A. Comply with NECA 1.
B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. 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.
7. 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.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
10. 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 (12 mm) from the point of termination to maintain cable geometry.

D. Group connecting hardware for cables into separate logical fields.

E. 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:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
   3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
   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 (76 mm).
      c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
   5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
   6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.
3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 2.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Section 099123 "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/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

D. 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.

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. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner. Provide three (3) hard copies to owner. Provide one (1) drawing in each equipment room and wiring closet and post in a prominent location. Protect with rigid frame and clear plastic cover.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. 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.

3. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.
4. Meet with Davis School District Security personnel and coordinate labeling requirements prior to installation.

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/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.
3.7 GROUNDING

A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.

B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.

D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."

1. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified.
2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."

D. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."

E. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."
END OF SECTION 28 1600
SECTION 28 2300
VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Provide Communications Horizontal Cabling for all video surveillance cameras. Refer to Section 27 1500, “Communications Horizontal Cabling”.
B. Install rack and NVR for video surveillance camera. Rack and NVR furnished by Owner.
C. Install and connect cameras for video surveillance. Cameras furnished by Owner

1.3 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

   1. Interior, Controlled Environment: System components installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
   2. Interior, Uncontrolled Environment: System components installed in non-air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, type 12 enclosures.
   3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick. Use NEMA 250, Type 3R enclosures.
PART 2 - PRODUCTS

2.1  Not used.

PART 3 - EXECUTION

3.1  EXAMINATION

A.  Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.

B.  Examine roughing-in for LAN, WAN, and IP network before device installation.

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

3.2  WIRING

A.  Install cables in raceways and cable trays except above lay-in tile accessible ceilings. Install cables in raceway where routed in consoles, cabinets, desks, and counters. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment. Where cables are routed above accessible lay-in tile suspended ceilings, secure and support cables with J-hooks a minimum of 8 inches (200 mm) above ceilings and not more than 60 inches (1524 mm) apart; cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Install cables in open ceilings (finished and unfinished) in raceways. Where raceways are installed in finished ceilings, paint raceways to match the color of the surrounding surface.

1.  Install plenum cable in environmental air spaces, including plenum ceilings.

2.  Comply with requirements in Section 260110 “Conduit Raceways.” Minimum raceway size is ¾”.

3.  Comply with requirements in Section 260111 “Cable Trays.”

B.  Conceal raceway and cables except in unfinished spaces.

C.  In open ceilings and unfinished spaces, install wiring in exposed raceway.

D.  Refer to Section 26 0110, “Conduit Raceways” for conduit raceways and Section 27 1000, “Network Cabling” for cable tray.

E.  Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer’s limitations on bending radii. Provide and use lacing bars and distribution spools.

F.  Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. 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.

G.  For LAN connection and copper communication wiring, comply with Section 27 1000 “Network Cabling”. Use UL-listed plenum cable throughout the entire system.
H. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras and infrared illuminators level and plumb.

B. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings or as otherwise indicated on drawings. Change type of mounting to achieve required clearance.

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
   2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
      a. Prepare equipment list described in "Informational Submittals" Article.
      b. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
      c. Set and name all preset positions; consult Owner's personnel.
      d. Set sensitivity of motion detection.
      e. Connect and verify responses to alarms.
      f. Verify operation of control-station equipment.
   3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
   4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

D. Video surveillance system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Update cameras with the latest recommended firmware.
G. Label physical camera according to School District Standards.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows and lenses.

END OF SECTION 28 2300
Ellis Elementary

TECHNICAL SPECIFICATIONS

Section 311000  Site Clearing
Section 312200  Site Excavation and Rough Grading
Section 312300  Earthwork
Section 312500  Erosion Control
Section 321216  Asphalt Paving
Section 321313  Concrete Paving
Section 321373  Concrete Paving Joint Sealants
Section 321723  Paving Striping and Marking
Section 331100  Potable Water Systems
Section 331119  Fire Suppression Water Systems
Section 333100  Sanitary Sewage Systems
Section 334100  Storm Drainage
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SECTION 31 1000
SITE CLEARING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. This Section includes the following:
      1. Removing trees and other vegetation.
      2. Clearing and grubbing.
      3. Topsoil stripping.
      4. Removing above-grade site improvements.
      5. Disconnecting, capping or sealing, and removing site utilities.
   B. Related Sections include the following:
      1. Division 1 Section “Temporary Facilities and Controls” for temporary utilities,
         temporary construction and support facilities, temporary security and protection
         facilities, and environmental protection measures during site operations.
      2. Division 31 Section "Earthwork" for soil materials, excavating, backfilling, and site
         grading.

1.03 DEFINITIONS
   A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt,
      and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than
      underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more
      than 2 inches (50 mm) in diameter; and free of weeds, roots, and other deleterious
      materials.

1.04 MATERIALS OWNERSHIP
   A. Materials indicated to be stockpiled or to remain are the Owner's property. Cleared
      materials shall become Contractor's property and shall be removed from the site.

1.05 SUBMITTALS
   A. Photographs, DVD or videotape, sufficiently detailed, of existing conditions of trees and
      plantings, adjoining construction, and site improvements that might be misconstrued as
      damage caused by site clearing.
   B. Record drawings according to Division 1 Section "Closeout Procedures."
      1. Identify and accurately locate capped utilities and other subsurface structural,
         electrical, and mechanical conditions.

1.06 QUALITY ASSURANCE
   A. Pre-installation Conference: Conduct conference at Project site to comply with
      requirements in Division 1 Section "Project Meetings."

1.07 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 Owner and authorities having jurisdiction.
      2. Provide alternate routes around closed or obstructed traffic ways if required by
         Owner or authorities having jurisdiction.
   B. Improvements on Adjoining Property: Authority for performing indicated removal and/or
      access on property adjoining Owner's property will be obtained by Owner before award of
Contract.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Notification: Notify utility locator service for area where Project is located before site clearing.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Locate and clearly flag trees and vegetation to remain or to be relocated.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.02 TREE PROTECTION

A. Erect and maintain a temporary fence around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove fence when construction is complete.
   1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
   2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.

B. Do not excavate within drip line of trees, unless otherwise indicated.

C. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-line spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
   1. Cover exposed roots with burlap and water regularly.
   2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
   3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
   4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
   1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.03 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
   1. Arrange to shut off indicated utilities with utility companies.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Excavate for and remove underground utilities indicated to be removed.

3.04 CLEARING AND GRUBBING
A. Remove obstructions, asphalt & concrete paving, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
   3. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18 inches (450 mm) below exposed subgrade.
   4. Use only hand methods for grubbing within drip line of remaining trees.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding 8-inch (200-mm) loose depth, and compact each layer to a density equal to adjacent original ground.

3.05 TOPSOIL STRIPPING
A. Remove sod, grass, asphalt and concrete paving before stripping topsoil.
B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Limit height of topsoil stockpiles to 72 inches (1800 mm).
   2. Do not stockpile topsoil within drip line of remaining trees.
   3. Dispose of excess topsoil as specified for waste material disposal.
   4. Stockpile surplus topsoil and allow for respreading deeper topsoil.

3.06 SITE IMPROVEMENTS
A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

3.07 DISPOSAL
A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION
SECTION 31 22 00
SITE EXCAVATION AND ROUGH GRADING

PART 1 -GENERAL

1.01 DESCRIPTION
A. Definitions:
   1. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.
   2. Engineer: Soils Engineer employed by Owner, empowered to conduct inspections and make approvals.

1.02 QUALITY ASSURANCE
A. Compaction density test:
   1. Modified Proctor, ASTM-D 1557.
B. Layout work by Surveyor or Civil Engineer registered in the State of Utah. Identify benchmark to be used in establishing grades.
C. Owner will hire an independent soils laboratory to conduct in place moisture and density tests.
D. Tolerances of sub-grade:
   1. Unsurfaced areas: Plus/minus 0.20 FT from required elevations.
   2. Paved areas: Plus/minus 0.10 FT from required elevations.

1.03 JOB CONDITIONS
A. Protect existing facilities, utilities (overhead and underground), sidewalks, pavement.
   1. Repair damaged items.
   2. Notify Owner and make emergency repair as directed.
B. Protect graded areas against erosion.
   1. Re-establish grade where settlement or washing occurs at no extra cost.

PART 2 -PRODUCTS

2.01 MATERIALS
A. Fill materials:
   1. Reasonably free of roots, organic material, trash, frozen matter, and stones larger than 6 IN.
   2. Add water to dry material, as required.
   3. Allow wet material to dry, as required.
   4. Fill can only be obtained on site where removed from excavating and grading.
   5. Provide additional off-site borrow or fill as required.

B. Surplus material:
   1. Remove from site.

PART 3 -EXECUTION

3.01 PREPARATION
A. Layout units, structures, piping, roads, parking areas and walks and establish their elevations.
3.02 GENERAL

A. Excavate and grade materials to design elevations.
B. Excavate and grade site to subgrades of paved and unpaved areas as indicated.
C. Excavate for miscellaneous footings, slabs, walks and other structures.
D. Cut and fill as required to bring existing grades to rough grades.
E. Furnish and place additional approved material required to bring subgrade to proper line and grade.
F. During construction, shape and drain embankments and excavation.
G. Maintain ditches and drains to provide drainage.
H. Provide pumping if required.
I. Remove unsuitable materials which cannot be compacted as specified and replace with suitable material.
   1. Dispose material on site as directed.
   2. Dispose material off site as directed.
J. Remove materials unsuitable to receive fill and replace with suitable material.

3.03 CONSTRUCTION OF EMBANKMENTS AND FILLS

A. Construct embankments and fills to lines and grades.
B. Make completed fill correspond to shape of typical cross section or contour indicated regardless of method used to indicate shape, size, and extent of line and grade of work.
C. Insure that cobbles larger than 4 IN, are not placed in upper 6 IN of fill or embankment.
D. Place material in lifts, maximum 8 IN loose thickness.
E. Place layers horizontally and compact each layer to specified density prior to placing additional fill.
F. Compact using suitable equipment.
   1. Control moisture to meet requirements of compaction.
   2. Place materials within 3 percent above to 3 percent below optimum moisture content.
G. Under roadways and parking areas and extending 1 FT beyond proposed curb line measured perpendicular from centerline, compact to 96 percent maximum dry density.
H. Under walk paving, compact to 95 percent maximum dry density.
I. For other embankments and fills not listed, compact to 90 percent of maximum dry density.
J. Under proposed building and structures, compact to density as specified in Section 31 23 00.

END OF SECTION
SECTION 31 2300
EARTHWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY
A. This Section includes the following:
   1. Preparing subgrades for slabs-on-grade, walks, pavements, lawns, and plantings.
   2. Excavating and backfilling for buildings and structures.
   3. Drainage course for slabs-on-grade.
   4. Subbase course for concrete walks and pavements.
   5. Base course for asphalt paving.
   6. Subsurface drainage backfill for walls and trenches.
   7. Excavating and backfilling trenches within building lines.
   8. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

B. Related Sections include the following:
   1. Division 1 Section "Construction Facilities and Temporary Controls."
   2. Division 31 Section "Site Clearing" for site stripping, grubbing, removing topsoil, and protecting trees to remain.

1.03 DEFINITIONS
A. Backfill: Soil materials used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Layer placed between the subbase course and asphalt paving.
C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
D. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
E. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
F. Excavation: Removal of material encountered above subgrade elevations.
   1. Bulk Excavation: Excavations more than 10 feet (3 m) in width and pits more than 30 feet (9 m) in either length or width.
   2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.
H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
I. Subbase Course: Layer placed between the subgrade and base course for asphalt paving, or layer placed between the subgrade and a concrete pavement or walk.
J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

K. Utilities: Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.04 SUBMITTALS

A. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 1557 for each on-site or borrow soil material proposed for fill and backfill.

1.05 PROJECT CONDITIONS

A. Site Information: A Geotechnical Investigation of this site has been prepared. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that Owner will not be responsible for interpretations or conclusions drawn therefrom by Contractor. Data are made available for convenience of Contractor.

1. Additional test borings and other exploratory operations may be made by Contractor at no cost to Owner.

B. No additional monies for exporting or importing of soil.

1. As part of the Construction Documents, Owner may have provided Contractor with a Topographic Survey performed by manual or aerial means. Such Survey was prepared for project design purposes and is provided to the Contractor as a courtesy. It is expressly understood that such survey may not accurately reflect existing topographical conditions and typically will vary from actual conditions by a significant degree. It is the Contractor's responsibility to verify actual existing conditions by whatever means the Contractor deems appropriate. The Contractor shall be responsible for determining their own earthwork quantities and not rely on any estimate prepared by the Owner, its Agents or outside parties. The Contractor is responsible as part of its lump sum bid price for the project, for importing or exporting soils to achieve final sub-grades with suitable soils per the plans and specifications. No additional monies will be allowed beyond the Contractor's Lump Sum Bid Price for the project, for the exporting or importing of soils.

C. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
2. Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated:
3. Notify Architect not less than seven (7) days in advance of proposed utility interruptions.
4. Do not proceed with utility interruptions without Architect's written permission.
5. Contact utility-locator service for area where Project is located before excavating.

D. Utilities to be removed: Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.
E. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
   1. Operate warning lights as recommended by authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: ASTM D 2487 soil classification groups GW, GP, GM, SW, SP, and SM, or a combination of these group symbols; free of rock or gravel larger than 4 inches (100 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: ASTM D 2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, and PT, or a combination of these group symbols.
   1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Backfill and Fill: Satisfactory soil materials.

E. Subbase: Naturally or artificially well graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 70 percent passing a 3/4-inch (18-mm) sieve and not more than 25 percent passing a No. 200 (0.075-mm) sieve.

F. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; conforming to the 1 inch gradation requirements of Section 301 of the UDOT Standard Specification for Road and Bridge Construction.

G. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 70 percent passing a 3/4-inch (18-mm) sieve and not more than 25 percent passing a No. 200 (0.075-mm) sieve.

H. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

I. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (38-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.

J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.02 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
   2. Yellow: Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

C. Trace Wire: Insulated 10 gage copper, suitable for direct bury.

PART 3 - EXECUTION

3.01 PREPARATION
A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
C. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.02 DEWATERING
A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
   1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
   2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.03 EXPLOSIVES
A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL
A. Unclassified Excavation: Excavation to subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, and obstructions.
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.05 EXCAVATION FOR STRUCTURES
A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 0.1 FT (25 mm). Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. If required to not disturb bottom of excavation, excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Excavation for Underground Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 0.1 FT (25 mm). Do not disturb bottom of excavations intended for bearing surface.

3.06 EXCAVATION FOR WALKS AND PAVEMENTS
A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.
3.07 EXCAVATION FOR UTILITY TRENCHES

A. Trench Excavation: Excavate trenches to indicated gradients, lines, depths, and elevations.
   1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
   2. Trench Clearance: Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.
   3. Clearance: 12 inches (300 mm) on each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
   1. For pipes and conduit less than 6 inches (150 mm) in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   2. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
   3. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: Excavate trenches 4 inches (100 mm) deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.
   1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.08 TRENCH SUPPORT SYSTEMS

A. Trench support system shall be suitable for the soil structure, depth of cut, water content of soil, weather conditions, superimposed loads and vibration. Contractor may select one of the following methods of ensuring the safety of workers in the trench, as approved by the Utah State Industrial Commission or its safety inspectors:
   1. Sloping the sides of the trench to the angle of repose at which the soil will remain safely at rest.
   2. Shoring trench sides by placing sheeting, timber shore piles, or other materials to resist pressures surrounding the excavation.
   3. Using a movable trench box built-up of steel plates and heavy steel frame of sufficient strength to resist the pressures surrounding the excavation.

3.09 APPROVAL OF SUBGRADE

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades.

D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect.

3.10 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top
Elevation. Lean concrete fill may be used when approved by Architect.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Architect.

3.11 STORAGE OF SOIL MATERIALS

A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.

2. Surveying locations of underground utilities for record documents.

3. Inspecting and testing underground utilities.

4. Removing concrete formwork.

5. Removing trash and debris.

6. Removing temporary shoring and bracing, and sheeting.

7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.13 UTILITY TRENCH BACKFILL

A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings; fill with concrete to elevation of bottom of footings.

C. Provide 4-inch- (100-mm-) thick, concrete-base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway subbase.

D. Place and compact initial backfill of subbase material, free of particles larger than 1 inch (25 mm), to a height of 12 inches (300 mm) over the utility pipe or conduit.

1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

E. Coordinate backfilling with utilities testing.

F. Place and compact final backfill of satisfactory soil material to final subgrade.

G. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.14 FILL

A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.

B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

C. Place and compact fill material in layers to required elevations as follows:
1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

3.15 MOISTURE CONTROL
A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.
   1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
   2. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.16 COMPACTION OF BACKFILLS AND FILLS
A. Place backfill and fill materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) 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, and uniformly along the full length of each structure.
C. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
   1. Under structures, building slabs, steps, and pavements, scarify and recompact top 6 inches (150 mm) of existing subgrade and each layer of backfill or fill material at 95 percent. Compact to 98 percent for fills thicker than 6 feet deep.
   2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 95 percent.
   3. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 90 percent.

3.17 GRADING
A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
   1. Provide a smooth transition between adjacent existing grades and new grades.
   2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
   1. Lawn or Unpaved Areas: Plus or minus 0.2 FT (25 mm).
   2. Walks: Plus or minus 0.1 FT (25 mm).
   3. Pavements: Plus or minus 0.1 FT (13 mm).
C. Grading inside Building Lines: Finish subgrade to a tolerance of 0.1 FT (13 mm) when tested with a 10-foot (3-m) straightedge.

3.18 SUBBASE AND BASE COURSES
A. Under pavements and walks, place subbase course on prepared subgrade and as follows:
   1. Place base course material over subbase.
   2. Compact subbase and base courses at optimum moisture content to required
3. Shape subbase and base to required crown elevations and cross-slope grades.

4. When thickness of compacted subbase or base course is 6 inches (150 mm) or less, place materials in a single layer.

5. When thickness of compacted subbase or base course exceeds 6 inches (150 mm), place materials in equal layers, with no layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick when compacted.

B. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches (300 mm) wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.19 DRAINAGE COURSE

A. Under slabs-on-grade, place drainage course on prepared subgrade and as follows:

1. Compact drainage course to required cross sections and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

2. When compacted thickness of drainage course is 6 inches (150 mm) or less, place materials in a single layer.

3. When compacted thickness of drainage course exceeds 6 inches (150 mm), place materials in equal layers, with no layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick when compacted.

3.20 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 1000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than three tests.

2. Foundation Wall/Continuous Footing Backfill: At each compacted backfill layer, at least one test for each 15 linear feet or less of wall length, but no fewer than two tests.

3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each 40 feet or less of trench length, but no fewer than two tests.

4. Spot Footings: Minimum of 1 compaction test for each lift for each spot footing.

5. Sidewalks, Curbs, Gutters, Pads: Minimum of 1 test for each lift for each 40 lineal feet or 1 test for every 1000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.
3.21 PROTECTION
   A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
   B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
      1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompress.
   C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
      1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS
   A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION
SECTION 31 2500
EROSION CONTROL

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the work required for erosion control during construction. Any local or State Agency requirements will be considered part of these specifications.

B. Obtain the National Pollution Discharge Elimination System (NPDES) Permit for storm water discharge associated with construction activity.

C. Obtain a UPDES Storm Water General Permit for Construction Activities (Permit #UTR100000) or an alternate individual permit. Applications are available online at www.waterquality.utah.gov/UPDES/stormwater.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Silt fence shall be a woven fabric that meets the following criteria:

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<th>Property</th>
<th>Unit</th>
<th>Test Method</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Strength</td>
<td>lbs</td>
<td>ASTMD-4632</td>
<td>90 min</td>
</tr>
<tr>
<td>Grab Elongation</td>
<td>%</td>
<td>ASTMD-4632</td>
<td>40 max</td>
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<td>Water Flow Rate</td>
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<td>15 min</td>
</tr>
<tr>
<td>Ultraviolet Stability</td>
<td>%</td>
<td>ASTMD-4355</td>
<td>70% min</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 EXECUTION

A. Silt fence shall be placed in accordance with plans and details. The placement of silt fence and/or bales shall consider drainage paths and intercept drainage prior to leaving the site or entering a storm sewer system. Removal of silt and replacement of silt fence and/or bales shall be ongoing through the duration of the project to maintain an effective silt removing barrier.

B. Sediment Basin and/or sinks shall be constructed to dimensions shown on the plans. The basins and/or sinks shall be cleaned as required to maintain specified size and depth.

C. All temporary grading of drainage channels, slopes or fills shall be in accordance with Division 31 Section "Earthwork".

END OF SECTION
SECTION 32 1216

ASPHALT PAVING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.
5. Asphalt curbs.
6. Asphalt traffic-calming devices.
7. Asphalt surface treatments.
B. Related Requirements:
1. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.3 PREINSTALLATION MEETINGS
A. Preinstallation Conference: Conduct conference at site.
B. Review SECTION 013100 "Project Management and Coordination." for conference participants.
   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
      b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include technical data and tested physical and performance properties.
   2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
B. LEED Submittals:
   1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
C. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated:

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For manufacturer and testing agency.
B. Material Certificates: For each paving material. Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.
C. Material Test Reports: For each paving material, by a qualified testing agency.
D. Field quality-control reports.

1.6 QUALITY ASSURANCE
A. Manufacturer Qualifications: [A paving-mix manufacturer approved by engineer].
B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.
C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MILLVILLE CITY STANDARDS and UDOT for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS
A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Prime Coat: Minimum surface temperature of 60 deg F.
   2. Tack Coat: Minimum surface temperature of 60 deg F.
   4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
   5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS
2.1 AGGREGATES
A. General: Use materials and gradations that have performed satisfactorily in previous installations.
B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
C. Fine Aggregate: [ASTM D 1073] [or] [AASHTO M 29], sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
   1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
D. Mineral Filler: [ASTM D 242/D 242M] [or] [AASHTO M 17], rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS
A. Asphalt Binder: AASHTO M 320, [PG 58-28]
B. Asphalt Cement: [ASTM D 3381/D 3381M for viscosity-graded material] [ASTM D 946/D 946M for penetration-graded material].
C. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, [MC-30 or MC-70] [MC-250].
D. Emulsified Asphalt Prime Coat: [ASTM D 977] [or] [AASHTO M 140] emulsified asphalt, or [ASTM D 2397] [or] [AASHTO M 208] cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
E. Tack Coat: [ASTM D 977] [or] [AASHTO M 140] emulsified asphalt, or [ASTM D 2397] [or] [AASHTO M 208] cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.
F. Fog Seal: [ASTM D 977] [or] [AASHTO M 140] emulsified asphalt, or [ASTM D 2397] [or] [AASHTO M 208] cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.
2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled [tires] [asphalt shingles] [or] [glass] from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

C. Sand: [ASTM D 1073] [or] [AASHTO M 29], Grade No. 2 or No. 3.

D. Paving Geotextile: [AASHTO M 288] paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

E. Joint Sealant: [ASTM D 6690] [or] [AASHTO M 324], [Type I] [Type II or III] [Type IV], hot-applied, single-component, polymer-modified bituminous sealant.

2.4 MIXES

A. Recycled Content of Hot-Mix Asphalt: Post consumer recycled content plus one-half of preconsumer recycled content not less than [10] percent or more than [15] percent by weight.  
1. Surface Course Limit: Recycled content no more than [10] percent by weight.

B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes [approved by authorities having jurisdiction] [designed according to procedures in AIMS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"] and complying with the following requirements:
1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: 3/4"
3. Surface Course: 1/2"

C. Emulsified-Asphalt Slurry: ASTM D 3910, [Type 1] [Type 2] [Type 3].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

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

3.2 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
1. Mill to a depth of [2 inches]
2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Patch surface depressions deeper than 1 inch after milling, before wearing course is laid.
7. Handle milled asphalt material according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."
8. Keep milled pavement surface free of loose material and dust.
9. Do not allow milled materials to accumulate on-site.

3.3 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
   1. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
   2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd.
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

E. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.4 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.
   1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of [1/4 inch]
   1. Clean cracks and joints in existing hot-mix asphalt pavement.
   2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.
   3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.5 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
B. Herbicide Treatment: Apply herbicide according to manufacturer’s recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
   1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
C. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd.. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
   1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
   2. Protect primed substrate from damage until ready to receive paving.
D. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.10 to 0.30 gal./sq. yd. per inch depth. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
   1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
   2. Protect primed substrate from damage until ready to receive paving.
E. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.6 PAVING GEOTEXTILE INSTALLATION
A. Apply [tack coat] [asphalt binder] [asphalt cement] uniformly to existing pavement surfaces at a rate of 0.20 to 0.30 gal./sq. yd.
B. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches and transverse joints 6 inches
C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

3.7 PLACING HOT-MIX ASPHALT
A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
   2. Place hot-mix asphalt surface course in single lift.
   3. Spread mix at a minimum temperature of 250 deg F
   4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
   5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.

2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.8 JOINTS
A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.

2. Offset longitudinal joints, in successive courses, a minimum of 6 inches

3. Offset transverse joints, in successive courses, a minimum of 24 inches

4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints [using either "bulkhead" or "papered" method according to Al MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."] Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.

5. Compact asphalt at joints to a density within 2 percent of specified course density.

3.9 COMPACTION
A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to [ASTM D 6927] or [AASHTO T 245], but not less than 94 percent or greater than 100 percent.

2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.
3.10 ASPHALT CURBS
   A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F
   1. Asphalt Mix: Same as pavement surface-course mix.
   B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.11 ASPHALT TRAFFIC-CALMING DEVICES
   A. Construct hot-mix asphalt speed [bumps] [humps] [cushions] [and] [tables] over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F
   1. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
   2. Asphalt Mix: Same as pavement surface-course mix.
   3. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of 1 inch from top of pavement to a clean, rough profile.
   B. Place and compact hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.12 INSTALLATION TOLERANCES
   A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
      1. Base Course: Plus or minus 1/2 inch
      2. Surface Course: Plus 1/4 inch no minus.
   B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
      1. Base Course: [1/4 inch]
      2. Surface Course: [1/8 inch]
      3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch
   C. Asphalt Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus 1/8 inch of height indicated above pavement surface.

3.13 SURFACE TREATMENTS
   A. Fog Seals: Apply fog seal at a rate of 0.10 to 0.15 gal./sq. yd. to existing asphalt pavement and allow to cure. With fine sand, lightly dust areas receiving excess fog seal.
   B. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to cure.
      1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

3.14 FIELD QUALITY CONTROL
   A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
   B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
   C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to [ASTM D 979] [or] [AASHTO T 168].

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.

2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
   a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
   b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.15 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION
SECTION 32 1313  
CONCRETE PAVING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.
B. Related Sections:
   1. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

1.3 DEFINITIONS
A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.
C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.
D. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
   1. Exposed Aggregate: \([10\text{-lb}]\) Sample of each mix.
   2. Wheel Stops: \([6\text{ inches long}]\) showing cross section; with fasteners.
   3. Preformed Traffic-Calming Devices: \([6\text{ inches long}]\) showing cross section; with fasteners.
E. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For qualified [Installer of detectable warnings] [ready-mix concrete manufacturer] [and] [testing agency].
B. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Steel reinforcement and reinforcement accessories.
   3. Fiber reinforcement.
   4. Admixtures.
5. Curing compounds.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

C. Material Test Reports: For each of the following:
   1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 unless otherwise indicated.

F. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
   2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 96 inches by 96 inches. Include full-size detectable warning.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

G. Preinstallation Conference: Conduct conference at site.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.

   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
d. Concrete paving subcontractor.
e. Manufacturer's representative of stamped concrete paving system used for detectable warnings.

1.7 PROJECT CONDITIONS
A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of [40 deg F for oil-based materials] [55 deg F for water-based materials], and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 FORMS
A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
   1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. [Do not use notched and bent forms.]
B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT
A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] percent.
B. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from [galvanized-steel wire into flat sheets.]
E. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
F. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 deformed bars.
G. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.
H. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 deformed bars; assembled with clips.
I. Plain-Steel Wire: ASTM A 82/A 82M, [galvanized].
J. Deformed-Steel Wire: ASTM A 496/A 496M.
K. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, [plain].
L. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars; zinc coated (galvanized) after fabrication according to ASTM A 767/A 767M, Class I coating. Cut bars true to length with ends square and free of burrs.
M. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain-steel bars.
N. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.
O. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
P. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar
supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

Q. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.


2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150, [gray] [white] portland cement [Type I] [Type II] [Type I/II] [Type III] [Type V]. [Supplement with the following:]
   a. Fly Ash: ASTM C 618, [Class C] [or] [Class F].
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.


B. Normal-Weight Aggregates: ASTM C 33, [Class 4S] [Class 4M] [Class 1N], uniformly graded. Provide aggregates from a single source [with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials].

2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

2. Aggregate Source, Shape, and Color:

D. Water: Potable and complying with ASTM C 94/C 94M.


F. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

G. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable,[free of carbon black,] nonfading, and resistant to lime and other alkalis.

1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following]:
   a. ChemMasters.
b. **Davis Colors.**
c. **Dayton Superior Corporation.**
d. **Elementis Pigments.**
e. **Hoover Color Corporation.**
f. **Lambert Corporation.**
g. **LANXESS Corporation.**
h. **QC Construction Products.**
i. **Scofield, L. M. Company.**
j. **Solomon Colors, Inc.**
k. **Stampcrete International, Ltd.**
l. **SureCrete Design Products.**

2. **Color:** [As selected by Architect from manufacturer's full range].

2.4 **FIBER REINFORCEMENT**

A. **Synthetic Fiber:** [Monofilament] [or] [fibrillated] polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, [1/2 to 1-1/2 inches] long.

1. **Products:** Subject to compliance with requirements, [provide one of the following]:
   a. **Monofilament Fibers:**
      1) *Axim Italcementi Group, Inc.; FIBRASOL II P.*
      2) *Euclid Chemical Company (The), an RPM company; Fiberstrand 100, Fiberstrand 150.*
      3) *FORTA Corporation; [FORTA ECONO-MONO] [or] [FORTA Mighty-Mono].*
      5) *Metalcrete Industries; Polystrand 1000.*
      6) *QC Construction Products; QC FIBERS.*
   b. **Fibrillated Fibers:**
      1) *Axim Italcementi Group, Inc.; FIBRASOL F.*
      2) *Euclid Chemical Company (The), an RPM company; Fiberstrand F.*
      3) *FORTA Corporation; [FORTA Econo-Net] [or] [FORTA Super-Net].*
      4) *Grace, W. R. & Co. - Conn.; Grace Fibers.*
      5) *Propex Concrete Systems Corp.; Fibermesh 300.*

2.5 **CURING MATERIALS**

A. **Absorptive Cover:** AASHTO M 182, [Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry] [or] [cotton mats].

B. **Moisture-Retaining Cover:** ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. **Water:** Potable.

D. **Evaporation Retarder:** Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

1. **Products:** Subject to compliance with requirements, [provide one of the following]:
   a. *Axim Italcementi Group, Inc.; Caltexol CIMFILM.*
   b. *BASF Construction Chemicals, LLC; Confilm.*
   c. *ChemMasters; Spray-Film.*
   d. *Conspec by Dayton Superior; Aquafilm.*
e. **Dayton Superior Corporation**: Sure Film (J-74).

f. **Edoco by Dayton Superior**: BurkeFilm.

g. **Euclid Chemical Company (The)**, an RPM company; Eucobar.

h. **Kaufman Products, Inc.**: VaporAid.

i. **Lambert Corporation**: LAMBCO Skin.

j. **L&M Construction Chemicals, Inc.**: E-CON.

k. **Meadows, W. R., Inc.**: EVAPRE.

l. **Metalcrete Industries**: Waterhold.

m. **Nox-Crete Products Group**: MONOFILM.

n. **Sika Corporation, Inc.**: SikaFilm.

o. **SpecChem, LLC**: Spec Film.

p. **Symons by Dayton Superior**: Finishing Aid.

q. **TK Products**, Division of Sierra Corporation; TK-2120 TRI-FILM.

r. **Unitex**: PRO-FILM.

s. **Vexcon Chemicals Inc.**: Certi-Vex EnvioAssist.

E. **Clear, Waterborne, Membrane-Forming Curing Compound**: ASTM C 309, Type 1, Class B, dissipating.

1. **Products**: Subject to compliance with requirements, [provide one of the following]:

   a. **Anti-Hydro International, Inc.**: A-H Curing Compound #2 DR WB.

   b. **ChemMasters**: Safe-Cure Clear.

   c. **Conspec by Dayton Superior**: [D.O.T. Resin Cure] [DSSCC Clear Resin Cure].

   d. **Dayton Superior Corporation**: Day-Chem Rez Cure (J-11-W).

   e. **Edoco by Dayton Superior**: [DSSCC Clear Resin Cure] [Resin Emulsion Cure V.O.C. (Type I)].

   f. **Euclid Chemical Company (The)**, an RPM company; Kurez W VOX.

   g. **Kaufman Products, Inc.**: Thinfilm 420.

   h. **Lambert Corporation**: AQUA KURE - CLEAR.

   i. **L&M Construction Chemicals, Inc.**: L&M CURE R.

   j. **Meadows, W. R., Inc.**: 1100-CLEAR SERIES.

   k. **Nox-Crete Products Group**: Resin Cure E.

   l. **SpecChem, LLC**: PaveCure Rez.

   m. **Symons by Dayton Superior**: Resi-Chem Clear.

   n. **Tamms Industries, Inc.**, Euclid Chemical Company (The); TAMMSCURE WB 30C.

   o. **TK Products**, Division of Sierra Corporation; [TK-2519 WB] [TK-2519 DC WB].

   p. **Vexcon Chemicals Inc.**: Certi-Vex Enviocure 100.

F. **White, Waterborne, Membrane-Forming Curing Compound**: ASTM C 309, Type 2, Class B, dissipating.

1. **Products**: Subject to compliance with requirements, [provide one of the following]:

   a. **Anti-Hydro International, Inc.**: A-H Curing Compound #2 WP WB.


   c. **Conspec by Dayton Superior**: [D.O.T. Resin Cure White] [DSSCC White Resin Cure].
d. Dayton Superior Corporation; Day-Chem White Pigmented Cure (J-10-W).
e. Edoco by Dayton Superior; Resin Emulsion Cure V.O.C. (Type II).
f. Euclid Chemical Company (The), an RPM company; Kurez VOX White Pigmented.
g. Kaufman Products, Inc.; Thinfilm 450.
h. Lambert Corporation; AQUA KURE - WHITE.
i. L&M Construction Chemicals, Inc.; L&M CURE R-2.
j. Meadows, W. R., Inc.; 1100-WHITE SERIES.
k. SpecChem, LLC; PaveCure Rez White.
l. Symons by Dayton Superior; Resi-Chem White.
m. Vexcon Chemicals Inc.; Certi-Vex Enviocure White 100.

2.6 RELATED MATERIALS

A. Joint Fillers: [ASTM D 1751, asphalt-saturated cellulosic fiber] [or] [ASTM D 1752, cork or self-expanding cork] in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

C. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
   1. [Types I and II, non-load bearing] [Types IV and V, load bearing], for bonding hardened or freshly mixed concrete to hardened concrete.

E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch.
   1. Products: Subject to compliance with requirements, [provide one of the following]:
      a. ChemMasters; Exposee.
      b. Conspec by Dayton Superior; Delay S.
      c. Dayton Superior Corporation; Sure Etch (J-73).
      d. Edoco by Dayton Superior; True Etch Surface Retarder.
      e. Euclid Chemical Company (The), an RPM company; Surface Retarder Formula S.
      g. Meadows, W. R., Inc.; TOP-STOP.
      h. Metalcrete Industries; Surf tard.
      i. Nox-Crete Products Group; CRETE-NOX TA.
      j. Scofield, L. M. Company; LITHOTEX Top Surface Retarder.
      k. Sika Corporation, Inc.; Rugasol-S.
      l. SpecChem, LLC; Spec Etch.
      m. TK Products, Division of Sierra Corporation; TK-6000 Concrete Surface Retarder.
      n. Unitex; TOP-ETCH Surface Retarder.
      o. Vexcon Chemicals Inc.; Certi-Vex Enviocure.
F. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Products: Subject to compliance with requirements, [provide one of the following]:
   b. BASF Construction Chemicals, LLC; Mastercron.
   c. ChemMasters; ConColor.
   d. Conspec by Dayton Superior; Conshake 600 Colortone.
   e. Dayton Superior Corporation; Quartz Tuff.
   f. Euclid Chemical Company (The), an RPM company; Surflex.
   g. Lambert Corporation; COLORHARD.
   h. L&M Construction Chemicals, Inc.; QUARTZPLATE FF.
   i. Metalcrete Industries; Floor Quartz.
   j. Scofield, L. M. Company; LITHOCHROME Color Hardener.
   k. Southern Color N.A., Inc.; Mosaics Color Hardener.
   l. Stampcrete International, Ltd.; Color Hardener.
   m. Symons by Dayton Superior; Hard Top.

2. Color [As selected by Architect from manufacturer’s full range]

G. Rock Salt: Sodium chloride crystals, kiln dried, coarse gradation with 100 percent passing 3/8-inch sieve and 85 percent retained on a No. 8 sieve.

2.7 PAVEMENT MARKINGS

A. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, [Type N] [Type F] [Type S]; colors complying with FS TT-P-1952.

1. Color: [As indicated]

B. Pavement-Marking Paint: MPI #32 Alkyd Traffic Marking Paint.

1. Color: [As indicated]

C. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than [45] minutes.

1. Color: [As indicated]


1. Color: [As indicated]

E. Glass Beads: [AASHTO M 247, Type 1].

2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): [4000 psi]
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: [0.44].
3. Slump Limit: [5 inches], plus or minus 1 inch.
C. Add air-entraining admixture at manufacturer’s prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   1. Air Content: \([5\text{-}1/2]\) percent plus or minus 1.5 percent for 1-1/2-inch nominal maximum aggregate size.
   2. Air Content: \([6]\) percent plus or minus 1.5 percent for 1-inch nominal maximum aggregate size.
   3. Air Content: \([6]\) percent plus or minus 1.5 percent for 3/4-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to \([0.15]\) percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer’s written instructions.
   1. Use \([\text{plasticizing and retarding admixture}]\) in concrete as required for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
   1. Fly Ash or Pozzolan: 25 percent.
   2. Ground Granulated Blast-Furnace Slag: 50 percent.
   3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

G. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer’s recommended rate, but not less than \([2.0 \text{ lb/cu. yd.}]\).

H. Color Pigment: Add color pigment to concrete mixture according to manufacturer’s written instructions and to result in hardened concrete color consistent with approved mockup.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M\([\text{and ASTM C 1116/C 1116M}]\). Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
   3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION
3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below \([\text{concrete paving}]\) to identify soft pockets and areas of excess yielding.
1. Completely proof-roll subbase in one direction[and repeat in perpendicular direction]. Limit vehicle speed to 3 mph.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of [1/2 inch] according to requirements in Section 312000 "Earth Moving."

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

3.2 PREPARATION
A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION
A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT
A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.
F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.
G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS
A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use [bonding agent] [epoxy bonding adhesive] at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
5. **Doweled Joints:** Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. **Isolation Joints:** Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals of [50 feet] unless otherwise indicated.
   2. Extend joint fillers full width and depth of joint.
   3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
   4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
   5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
   6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. **Contraction Joints:** Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows,[ to match jointing of existing adjacent concrete paving]:
   1. **Grooved Joints:** Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a [1/4-inch] [3/8-inch] radius. Repeat grooving of contraction joints after applying surface finishes.[ Eliminate grooving-tool marks on concrete surfaces.]
      a. **Tolerance:** Ensure that grooved joints are within [3 inches] either way from centers of dowels.
   2. **Sawed Joints:** Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
      a. **Tolerance:** Ensure that sawed joints are within [3 inches] either way from centers of dowels.
   3. **Doweled Contraction Joints:** Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. **Edging:** After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a [1/4-inch] radius. Repeat tooling of edges after applying surface finishes.[ Eliminate edging-tool marks on concrete surfaces.]

3.6 **CONCRETE PLACEMENT**

A. Before placing concrete, inspect and complete formwork installation[,] steel reinforcement,] and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement] before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

L. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.

2. Do not use frozen materials or materials containing ice or snow.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

M. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.

2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.8 SPECIAL FINISHES

A. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in paving surface as follows:
1. Immediately after float finishing, spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

B. Seeded Exposed-Aggregate Finish: Immediately after initial floating, spread a single layer of aggregate uniformly on paving surface. Tamp aggregate into plastic concrete and float finish to entirely embed aggregate with mortar cover of 1/16 inch.
1. Spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.
3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface according to manufacturer's written instructions and as follows:
1. Uniformly spread [40 lb/100 sq. ft.] of dampened, slip-resistive aggregate over paving surface in two applications. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.
2. Uniformly distribute approximately two-thirds of slip-resistive aggregate over paving surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second slip-resistive aggregate application, uniformly distributing remainder of material at right angles to first application to ensure uniform coverage, and embed by power floating.
3. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
4. After curing, lightly work surface with a steel wire brush or abrasive stone and water to expose nonslip aggregate.

D. Rock-Salt Finish: After initial [floating] [troweling] [brooming], uniformly spread rock salt over paving surface at the rate of 5 lb/100 sq. ft.
1. Embed rock salt into plastic concrete with [magnesium float].
2. Cover paving surface with 1-mil-thick polyethylene sheet and remove sheet when concrete has hardened and seven-day curing period has elapsed.
3. After seven-day curing period, saturate concrete with water and broom-sweep surface to dissolve remaining rock salt, thereby leaving pits and holes.
E. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surface according to manufacturer's written instructions and as follows:

1. Uniformly spread dry-shake hardener at a rate of [100 lb/100 sq. ft.], unless greater amount is recommended by manufacturer to match paving color required.

2. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.

3. After final power floating, apply a hand-trowel finish followed by a broom finish.

4. Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

3.9 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by [curing compound] [or] [a combination of these] as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.10 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch.


3. Surface: Gap below 10-foot-long, leveled straightedge not to exceed 1/2 inch.

4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.

5. Lateral Alignment and Spacing of Dowels: 1 inch.

6. Vertical Alignment of Dowels: 1/4 inch
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
8. Joint Spacing: 3 inches.

3.11 PAVEMENT MARKING
A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
B. Allow concrete paving to cure for a minimum of [28] days and be dry before starting pavement marking.
C. Sweep and clean surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.
   1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to concrete surface. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.
   2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal.

3.12 WHEEL STOPS
A. Install wheel stops in bed of adhesive applied as recommended by manufacturer.
B. Securely attach wheel stops to paving with not less than two [galvanized]-steel dowels located at one-quarter to one-third points. Install dowels in drilled holes in the paving and bond dowels to wheel stop. Recess head of dowel beneath top of wheel stop.

3.13 PREFORMED TRAFFIC-CALMING DEVICES
A. Install preformed speed [bumps] in bed of adhesive applied as recommended by manufacturer for heavy traffic.
B. Securely attach preformed speed [bumps] to paving with hardware spaced as recommended by manufacturer for heavy traffic. Recess head of hardware beneath top surface.

3.14 FIELD QUALITY CONTROL
A. Testing Agency: [Owner will engage] a qualified testing agency to perform tests and inspections.
B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each [100 cu. yd.] or [5000 sq. ft.] or fraction thereof of each concrete mixture placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.

6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
   a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.15 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION
SECTION 32 1373
CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Cold-applied, fuel-resistant joint sealants.
5. Joint-sealant backer materials.
6. Primers.
B. Related Requirements:
1. Section 079200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not
specified in this Section.

1.3 PREINSTALLATION MEETINGS
A. Preinstallation Conference: Conduct conference at the site.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Samples for Verification: For each kind and color of joint sealant required, provide Samples
with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material
matching the appearance of exposed surfaces adjacent to joint sealants.
C. Paving-Joint-Sealant Schedule: Include the following information:
1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For [Installer] [testing agency].
B. Product Certificates: For each type of joint sealant and accessory.

1.6 QUALITY ASSURANCE
A. Installer Qualifications: An entity that employs installers and supervisors who are trained and
approved by manufacturer.
B. Product Testing: Test joint sealants using a qualified testing agency.

1.7 FIELD CONDITIONS
A. Do not proceed with installation of joint sealants under the following conditions:
1. When ambient and substrate temperature conditions are outside limits permitted by joint-
sealant manufacturer[ or are below 40 deg F ].
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for
applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type NS.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; RoadSaver Silicone.
      b. Dow Corning Corporation; 888.
      c. Pecora Corporation; 301 NS.

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; RoadSaver Silicone SL.
      b. Dow Corning Corporation; 890-SL.
      c. Pecora Corporation; 300 SL.

C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Meadows, W.R., Inc; Pourthane NS.

D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Meadows, W.R., Inc; Pourthane SL.

E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Pecora Corporation; [Dynatred] [Dynatrol II-SG] [Urexpan NR-200].

2.3 HOT-APPLIED JOINT SEALANTS

   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; [Asphalt Rubber Plus] [Asphalt Rubber Plus Type 2] [RoadSaver 203] [RoadSaver 211] [RoadSaver 515].
      b. Meadows, W.R., Inc; [Sealtight 1190] [Sealtight 164].
      c. Right Pointe.

B. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I or Type II.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; [RoadSaver 201] [RoadSaver 220] [RoadSaver 221] [RoadSaver 534].
      b. Right Pointe; [JTS 3405 Parking Lot Sealant 007] [JTS 3405 Rubber 009].
C. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I, II, or III.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; RoadSaver 222.
      b. Meadows, W.R.,Inc; Sealtight 3405.
      c. Right Pointe; [JTS 3405 Regular 003] [JTS 3405 Rubber 009].

D. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type IV.
   1. **Products:** Subject to compliance with requirements, [provide one of the following]:
      a. Crafco Inc; RoadSaver 231.
      b. Meadows, W.R.,Inc; Sealtight 3405M.

2.4 COLD-APPLIED, FUEL-RESISTANT JOINT SEALANTS
   A. Fuel-Resistant, Single-Component, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.
      1. **Products:** Subject to compliance with requirements, [provide one of the following]:
         a. BASF Building Systems; Sonomeric 1.

   B. Fuel-Resistant, Multicomponent, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 12-1/2 or 25, for Use T.
      1. **Products:** Subject to compliance with requirements, [provide one of the following]:
         a. Meadows, W.R.,Inc; Sealtight Gardox.
         b. Pecora Corporation; Urexpan NR-300.

2.5 HOT-APPLIED, FUEL-RESISTANT JOINT SEALANTS
   A. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants: ASTM D 7116, Type I or Type II.
      1. **Products:** Subject to compliance with requirements, [provide one of the following]:
         a. Crafco Inc; [Superseal 1614A] [Superseal 444/777].

      1. **Products:** Subject to compliance with requirements, [provide one of the following]:
         a. Crafco Inc; Superseal Low-Mod.

2.6 JOINT-SEALANT BACKER MATERIALS
   A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

   B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

   C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

   D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.7 PRIMERS
   A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS
A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.
C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.
D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:
   1. Place joint sealants so they fully contact joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION
A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.
B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.5 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within concrete paving[<PJS-#>].
   1. Joint Location:
      a. Expansion and isolation joints in concrete paving.
      b. Contraction joints in concrete paving.
      c. Other joints as indicated.
   2. Joint Sealant: [Single-component, self-leveling, silicone joint sealant]
   3. Joint-Sealant Color: [Manufacturer’s standard]

B. Joint-Sealant Application: Joints within concrete paving and between concrete and asphalt paving[<PJS-#>].
   1. Joint Location:
      a. Joints between concrete and asphalt paving.
      b. Joints between concrete curbs and asphalt paving.
      c. Other joints as indicated.
   2. Joint Sealant: [Hot-applied, single-component joint sealant]
   3. Joint-Sealant Color: [Manufacturer’s standard]

C. Joint-Sealant Application: Fuel-resistant joints within concrete paving[<PJS-#>].
   1. Joint Location:
      a. Expansion and isolation joints in concrete paving.
      b. Contraction joints in concrete paving.
      c. Other joints as indicated.
   2. Joint Sealant: [Fuel-resistant, multicomponent, pourable, modified-urethane, elastomeric joint sealant]
   3. Joint-Sealant Color: [Manufacturer’s standard]

END OF SECTION
SECTION 32 1723
PAVING STRIPING AND MARKING

PART 1 -GENERAL

1.1 SUBMITTALS
A. Project information:
   1. Manufacturer of listed products.

1.2 JOB CONDITIONS
A. Do not paint when surface is wet, during wet or damp weather, or when temperature is below 40 degF.
B. Do not paint or install markers when surface is wet, during wet or damp weather, or when temperature is below 40 degF.
C. Painting Equipment:
   1. Self contained, self propelled striping machine.
   2. Capable of painting line 4 IN wide with spray nozzle.
   3. Paint kept in constant agitation and under pressure.

PART 2 -PRODUCTS

2.1 MATERIALS
A. Acceptable manufacturers:
   1. Paint:
      a. Base:
         1) ICI Paints.
      b. Optional:
         1) Sherwin-Williams.
   2. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 PAINT
A. Non-Reflective Paint:
   1. Description: Non-reflective paint conforming to F.S.TT-P-1952B.

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<tr>
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<td>Red</td>
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</tr>
<tr>
<td>Paint-out of existing</td>
<td>Black</td>
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</tr>
<tr>
<td>items</td>
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PART 3 -EXECUTION

3.1 PREPARATION OF SURFACE
   A. Do not paint until a minimum of 5 days has elapsed from time surface is completed or cured.
      1. A longer period of time may be required if directed by Architect.
   B. Thoroughly clean surfaces to receive striping or marking.
   C. Assure surface is dry.

3.2 PAINTING
   A. Mark and stripe in accordance with applicable drawings with approved striping machine.
   B. Width of painted lines: 4 IN.
   C. Provide painted accessible symbols in handicapped parking stalls.
   D. Use a guide to form markings true to line and width.
   E. Keep paints thoroughly stirred and of uniform consistency during application.
   F. Do not thin in excess of manufacturer’s recommendations.
   G. Use rates of application sufficient to produce complete coverage without voids or thin spots.
      1. Minimum Dry Film Thickness: 7mil.
   H. Overpaint unsatisfactory markings as directed by Architect.
   I. Protect marking from traffic until paint has dried to prevent tracking.

3.3 CLEANING UP
   A. Place rags and waste which might constitute a fire hazard in metal containers or destroy at end of each work day.
   B. Remove containers from site.
   C. Remove paint spots or stains on adjacent surfaces.
   D. Leave job clean and acceptable to Architect.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes potable water systems work.
B. Related Sections:
   1. Division 31 Section "Earthwork" for excavation and backfill required for potable water systems; not work of this section.
   2. Division 3 Sections for concrete work required for potable water systems; not work of this section.
   3. Division 22 Section "Potable Water Systems" for interior building systems including interior piping, fixtures, and equipment; not work of this section.

1.3 QUALITY ASSURANCE
A. Codes and Standards:
   1. Plumbing Code Compliance: Comply with applicable portions of National Standard Plumbing Code pertaining to selection and installation of potable water system materials and products.
   2. Water Purveyor Compliance: Comply with requirements of Purveyor supplying water to project, obtain required permits and inspections.
   3. Local Regulations: Comply with governing regulations and standards of local government having jurisdiction.

1.4 SUBMITTALS
A. Product Data: Submit manufacturer's technical product data and installation instructions for potable water system materials and products.
B. Maintenance Data: Submit maintenance data and parts list for potable water system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Approved Manufacturers: Subject to compliance with requirements, provide products of one of the following:
   1. Plastic Line Markers
      a. Allen Systems Inc.
      b. Seton Name Plate Corp.
      c. Equal product as approved by Engineer.
   2. Gate Valves:
      a. Clow Corp; Valve Div.
      b. Dresser Mfg.; Div. of Dresser Industries.
      c. Fairbanks Co.
      d. Kennedy Valve; Div. of ITT Grinnell Valve Co. Inc.
      e. Stockham Valves and Fittings Inc.
2.2 IDENTIFICATION

A. Underground-Type Detectable Warning Tape (refer to Specification 31 23 00):
Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape,
intended for direct-burial service; not less than 6” wide x 4 mils thick. Provide blue tape
with black printing reading "CAUTION WATER LINE BURIED BELOW".

B. Nonmetallic Piping Label: If nonmetallic piping is used for water service, provide
engraved plastic laminate, label permanently affixed to main electrical meter panel stating
"THIS STRUCTURE HAS A NONMETALLIC WATER SERVICE".

2.3 PIPES AND PIPE FITTINGS

A. Provide piping materials and factory-fabricated piping products of sizes, types, pressure
ratings, and capacities indicated. Where not indicated, provide proper selection as
determined by Installer to comply with installation requirements. Provide sizes and types
matching piping and equipment connections; provide fittings of materials which match
pipe materials used in potable water systems. Where more than one type of materials or
products are indicated, selection is Installer's option.

B. Piping: Provide pipe fittings and accessories of same material and weight/class as
pipes, with joining method as indicated.
1. PVC Pipe: Schedule 40 PVC, ASTM 1785 (1-1/2" to 2" pipe diameter). AWWA
   Pipe: C-900 class 150 (over 2" pipe diameter).
   a. fittings: Schedule 80 PVC fittings ASTM 1785.
2. Copper Tube: ASTM B 88; type K, soft-annealed temper (for 3/4" to 2" diameter
   pipe).
3. Ductile Iron Pipe: AWWA C151, with cement mortar lining complying with AWWA
   C104; Class 51 unless otherwise indicated.
   a. fittings: Ductile-Iron complying with AWWA C110, cement lined, with
      rubber gaskets conforming to AWWA C111.

2.4 VALVES

A. Gate Valves: AWWA C509, resilient seated 175 psi working pressure, threaded,
flanged, hub, or other end configurations to suit size of value and piping connection.
Provide inside screw type for use with curb valve box, iron body, bronze-mounted, double
disc, parallel seat, non-rising stem.

2.5 ACCESSORIES

A. 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.
2. Rods: Steel, ASTM A 575.
6. Thrust Blocks: Concrete, 2,500 psi.
casing, cast-iron or cast-aluminum casing guard, key-operated, and tapped drain
port in valve housing.
8. Valve Pits: Valve pits as indicated, constructed of poured-in-place or precast
concrete. Construct of dimensions indicated with manhole access, ladder, and
drain. Provide sleeves for pipe entry and exit, provide waterproof sleeve seals.
2.6 METERS
A. Meters and meter boxes shall be of the local Water District standards having jurisdiction.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine areas and conditions under which potable water system's materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF IDENTIFICATION
A. During back-filling/top-soiling of underground potable water piping, install continuous underground-type detectable warning tape (refer to Specification 02300), located directly over buried lines at 6" to 8" below finished grade.

3.3 INSTALLATION OF PIPE AND PIPE FITTINGS
A. Pipe:
   1. PVC Pipe: Install in accordance with manufacturers recommendations and sand bedding as required by authority having jurisdiction.
   2. Ductile Iron Pipe: Install in accordance with AWWA C600 "standard for installation of ductile-iron water mains and their appurtenances".
   3. Copper Tube: Install in accordance with CDA "Copper Tube Handbook".
B. Depth of Cover: Provide minimum cover over piping of 12" below average local frost depth or 60" below finished grade, whichever is greater.
C. Water Main Connection: Arrange and pay for tap in water main, of size and in location as indicated, from water Purveyor.
D. Water Service Termination: Terminate potable water piping 5'-0" from building foundation in location and invert as indicated. Provide temporary pipe plug for piping extension into building, by work of Division 15.
   1. Mark location with surface marker.
E. Runs shall be as close as possible to those shown on drawings.
F. Backfill only after pipe lines have been tested, inspected, and approved by the Architect.

3.4 INSTALLATION OF VALVES
A. Install valves with stems pointing up. Provide valve box over underground valves.

3.5 FIELD QUALITY CONTROL
A. Testing Agency: The Owner will employ and pay a qualified independent testing agency to perform field quality-control testing services specified in this section. Retesting of materials failing to meet specified requirements shall be done at Contractor's expense.
B. Piping Tests: Conduct piping tests before joints are covered, and after thrust blocks have sufficiently hardened. Fill pipeline 24-hrs. prior to testing, and apply test pressure to stabilize system. Use only potable water.
C. Hydrostatic Tests: Test at not less than 200 pounds per square inch for 2-hrs.
   1. Test fails if leakage exceeds 2-qts per hour per 100 gaskets or joints, irrespective of pipe diameter.
   2. Increase pressure in 50 psi increments and inspect each joint between increments. Hold at test pressure for one hour, decrease to 0 psi. Slowly increase again to test pressure and hold for one more hour.

3.6 ADJUSTING AND CLEANING
A. Disinfection of Potable Water System: Flush pipe system with clean potable water until no dirty water appears at point of outlet. Fill system with water-chlorine solution
containing at least 50 ppm of chlorine. Valve off system and let stand for 24-hrs minimum. Flush with clean potable water until no chlorine remains in water coming from system.

1. Repeat procedure if contamination is present in bacteriological examination.

B. Disinfection of Water Mains: Flush and disinfect in accordance with AWWA C652 "Standard for Disinfecting Water Mains".

1. Contractor shall submit written verification to Project Manager stating, Disinfection has been completed in strict compliance with specification for this project and with jurisdiction having authority over water system.

END OF SECTION
SECTION 33 1119
FIRE SUPPRESSION WATER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY.
A. Section includes fire water systems.
B. Related Sections:
   1. Division 31 Section "Earthwork" for excavation and backfill required for fire water systems; not work of this section.
   2. Refer to fire suppression sections for interior building systems including sprinklers and standpipes; this work is not included in this section.
      a. Refer to Division 21 Section Fire Suppression. Exterior water piping shall meet all requirements of this section. Test certificates are required.

1.2 QUALITY ASSURANCE
A. Codes and Standards:
   1. NFPA Compliance: Install fire water systems in accordance with NFPA 24 "Standard for Installation of Private Fire Service Mains and Their Appurtenances.
   B. Local Fire Department/Marshal Regulations: Comply with governing regulations pertaining to hydrants, including hose unit threading and similar matching of connections.
   C. UL Compliance: Provide fire hydrants that comply with UL 246 "Hydrants for Fire-Protection Service", and are listed by UL.

1.3 SUBMITTALS
A. Product Data: Submit manufacturer's technical product data and installation instructions for fire water system materials and products.
B. Maintenance Data: Submit maintenance data and parts lists for fire water system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURER:
A. Acceptable manufacturers: Subject to compliance with requirements, provide products of one of the following:
   1. Line Markers:
      a. Allen Systems Inc.
      b. Seton Name Plate Corp.
      c. Equal product as approved by Architect.
   2. Pipe Strainers:
      b. Cleveland Gear Co.; Sub of Vesper Corp.
      c. Grinnell Fire Protection Systems Co., Inc.
      d. Hersey Products Inc.; Hersey Div.
      e. Mueller Steam Specialty; Div. of Core Industries Inc.
      f. Neptune Water Meter Co.
      h. Rockwood Systems Corp.
i. Zurn Industries Inc.; Fluid Handling Div.

3. Detector Meter:
   a. Hersey Products Inc.

4. Gate Valves:
   b. American-Darling Valve; Div. of American Cast Iron Pipe Co.
   c. Clow Corp.; Valve Div.
   d. Fairbanks Co.
   e. Kennedy Valve; Div. of ITT Grinnell Valve Co., Inc.
   f. Stockham Valves & Fittings Inc.
   g. United Brass Works Inc.
   h. United States Pipe and Foundry Co.
   i. Waterous Co.

5. Check Valves:
   a. American-Darling Valve; Div. of American Cast Iron Pipe Co.
   b. Clow Corp.; Valve Corp.
   c. Fairbanks Co.
   d. Kennedy Valve; Div. of ITT Grinnell Valve Co., Inc.
   e. Mueller Co.
   f. Nibco Inc.
   g. Stockham Valves & Fittings Inc.
   h. Walworth Co.
   i. Waterous Co.

6. Fire Hydrants: As approved by authority having jurisdiction.

2.2 PIPES AND PIPE FITTINGS:

A. Provide materials and products complying with NFPA 24 where applicable. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in fire water piping systems. Where more than one type of materials or products are indicated, selection is Installer's option.

B. Piping: Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated. Minimum size of Fire Main serving Building Fire Sprinkler system on Fire Hydrants shall be 8 inches in diameter.

1. Ductile Iron Pipe: AWWA C151, with cement mortar lining complying with AWWA C104; Class 51 unless otherwise indicated.
   a. Fittings: Ductile-Iron complying with AWWA C110, cement lined, with rubber gaskets conforming to AWWA C111.

2. PVC Pipe: AWWA C-900, Class 150 unless otherwise indicated.
   a. Fittings: Schedule 80 PVC fittings complying with ASTM 1785.

2.3 PIPING SPECIALTIES:

A. Pipe Line Strainers: UL-listed, 175 psi working pressure, Y-type or basket type, with ends to suit piping connections.

2.4 METERS:

A. Detector-Type Meters: UL-listed, 175 psi working pressure, with disc meter bypass.
2.5 VALVES:
   A. Gate Valves: UL-listed, 175 psi working pressure for 12" and smaller, 150 psi for sizes larger than 12". Threaded, flanged, hub, or other end configurations to suit size of valve and piping connection. Inside screw type for use with indicator post, iron body bronze mounted, non-rising stem, solid wedge disc.
   B. Check Valves: UL-listed, 175 psi working pressure for 2" through 12", 150 psi for sizes larger than 12". Swing type, iron body bronze mounted with metal-to-metal or rubber-faced checks. Threaded, flanged, or hub end, to suit size and piping connections.

2.6 ACCESSORIES:
   A. Anchorage: 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.
   B. Clamps, Straps, and Washers: Steel, ASTM A 506.
   C. Rods: Steel, ASTM A 575.
   D. Rod Couplings: Malleable-iron, ASTM A 197.
   F. Cast-Iron Washers: Gray-iron, ASTM A 126.
   G. Thrust Blocks: Concrete, 2,500 psi.

PART 3 - EXECUTION
3.1 INSTALLATION
   A. Identification: During back-filling/top-soiling of underground fire water piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade.
   B. Pipe and pipe fittings:
      1. Ductile-Iron Pipe: Install in accordance with AWWA C600 "Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances".
      2. PVC Pipe: Install in accordance with manufacturers recommendations and provide pipe bedding as required by authority having jurisdiction.
   C. Piping Specialties:
      1. Pipe Line Strainers: Install as indicated, with valved blowoff piped to drain.
   D. Meters: Install as indicated with shutoff valve on either side of meter and valved bypass full line size.
   E. Valves: Provide post indicator for control valves.
      1. Shutoff Valves: Install shutoff valve ahead of each hydrant.
   F. Runs shall be as close as possible to those shown on drawings.

3.2 FIELD QUALITY CONTROL:
   A. Testing Agency: The Owner will employ and pay a qualified independent testing agency to perform field quality-control testing services specified in this section. Retesting of materials failing to meet specified requirements shall be done at Contractor's expense.
   B. Piping Tests: Conduct piping tests before joints are covered, and after thrust blocks have sufficiently hardened. Fill pipeline with water 24-hrs prior to testing, and apply test pressure to stabilize system.
   C. Hydrostatic Tests: Test at not less than 200 psi for 2-hrs, or at 50 psi above maximum static pressure if it is greater than 150 psi.
      1. Test fails if leakage exceeds 2-qts per hour per 100 gaskets or joints irrespective
of pipe diameter.

2. Increase pressure in 50 psi increments and inspect each joint between increments. Hold at test pressure for one hour, decrease to 0 psi. Slowly increase again to test pressure and hold for one more hour.

D. Operating Tests: Open and close all valves and hydrants under system water pressure. Check dry barrel hydrants for proper drainage.

1. For systems with fire pumps, run pumps during operating tests.

3.3 ADJUSTING AND CLEANING:

A. Flushing: Flush underground mains and lead-in connections to sprinkler risers before connection is made to sprinklers, standpipes, or other fire protection system piping.

1. Flush at flow rate not less than that indicated in NFPA 24, or at hydraulically calculated water demand rate of the system, whichever is greater.

B. Disinfection of Potable Water System: Flush pipe system with clean potable water until no dirty water appears at point of outlet. Fill system with water-chlorine solution containing at least 50 ppm of chlorine. Valve off system and let stand for 24- hrs minimum. Flush with clean potable water until no chlorine remains in water coming from system.

1. Repeat procedure if contamination is present in bacteriological examination.

C. Disinfection of Water Mains: Flush and disinfect in accordance with AWWA C652 "Standard for Disinfecting Water Mains".

1. Contractor shall submit written verification to Project Manager stating, Disinfection has been completed in strict compliance with specification for this project and with jurisdiction having authority over water system

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY.
A. Section includes sanitary sewage systems.
B. Related Sections:
   1. Refer to Division 31 section "Earthwork" for excavation and backfill required for sanitary sewage systems; not work of this section.
   2. Refer to Division 22 section "Soil and Waste Systems" for interior building systems including drain, waste, and vent piping; not work of this section.

1.2 QUALITY ASSURANCE:
A. Codes and Standards:
   2. Local Regulations: Comply with governing regulations and standards of local government having jurisdiction.

PART 2 - PRODUCTS

2.1 MANUFACTURER:
A. Acceptable Manufacturer: Subject to compliance with requirements, provide products of one of the following:
   1. Line Markers:
      a. Allen Systems, Inc.
      b. Emed Co., Inc.
      c. Seton Name Plate Corp.

2.2 IDENTIFICATION:
A. Underground-Type Detectable Warning Tape (refer to Specification 02300): Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide green tape with black printing reading "CAUTION SEWER LINE BURIED BELOW".

2.3 PIPES AND PIPE FITTINGS:
A. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated.
   1. Cast-Iron Soil Pipe: ASTM A 74, hub and spigot ends, service weight unless otherwise indicated.
      a. Fittings: Cast-iron hub and spigot ends, standard strength unless otherwise indicated.
   2. Concrete Pipe: ASTM C 14, Class III non-reinforced concrete pipe, unless otherwise indicated.
      a. Fittings: Concrete, same strength as adjoining pipe, tongue and groove gasketed joints complying with ASTM C 443.
   3. Polyvinyl Chloride (PVC) Sewer Pipe: ASTM D 3034, Type PSM, SDR 35.
      a. Fittings: ASTM 3034, bell and spigot joints.

2.4 SANITARY SEWER MANHOLES:
A. Provide precast reinforced concrete sanitary manholes as indicated, and complying with
ASTM C 478.
1. Top: Precast concrete, of concentric cone, eccentric cone, or flat slab top type, as indicated.
2. Base: Precast concrete, with base riser section and separate base slab, or base riser section with integral floor, as indicated.
3. Steps: Ductile-iron or aluminum, integrally cast into manhole sidewalls.
4. Frame and Cover: Ductile-iron, 21-3/4" diameter cover, heavy-duty, indented top design, with lettering cast into top reading "SANITARY SEWER".
5. Pipe Connectors: Resilient, complying with ASTM C 923.

2.5 CLEANOUTS:
A. Pipe extension to grade with ferrule and countersunk cleanout plug. Round cast-iron access frame over cleanout, with heavy-duty secured scoriated cover with lifting device.

PART 3 - EXECUTION

3.1 INSTALLATION OF IDENTIFICATION:
A. During back-filling/top-soiling of sanitary sewage systems, install continuous underground-type detectable warning tape, located directly over buried line at 6" to 8" below finished grade.

3.2 INSTALLATION OF PIPE AND FITTINGS:
A. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
   1. Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.
   2. Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.
   3. Place bell ends or groove ends of piping facing upstream.
   4. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.
   5. Runs shall be as close as possible to those shown on drawings.
B. Pipe:
   2. Concrete Pipe: Install in accordance with applicable provisions of ACPA "Concrete Pipe Installation Manual".
   3. Plastic Pipe: Install in accordance with manufacturer's installation recommendations, and in accordance with ASTM D 2321.
C. Cleaning Pipe: Clear interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed.
   1. In large, accessible piping, brushes and brooms may be used for cleaning.
   2. Place plugs in ends of uncompleted conduit at end of day or whenever work stops.
   3. Flush lines between manholes if required to remove collected debris.
D. Joint Adapters: Make joints between different types of pipe with standard manufactured adapters and fittings intended for that purpose.
E. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.
   1. Make inspections after lines between manholes, or manhole locations, have
been installed and approximately 2-ft of backfill is in place, and again at completion of project.

2. If inspection indicates poor alignment, debris, displaced pipe, infiltration, or other defects, correct such defects, and reinspect.

3.3 SANITARY MANHOLES:
A. Place precast concrete sections as indicated. Where manholes occur in pavements, set tops of frames and covers flush with finish surface. Elsewhere, set tops 3" above finish surface, unless otherwise indicated.
   1. Install in accordance with ASTM C 891.
   2. Apply bituminous mastic coating at joints of sections.

3.4 TAP CONNECTIONS:
A. Make connections to existing piping and underground structures, so that finished work will conform as nearly as practicable to requirements specified for new work.
B. Use commercially manufactured wyes for branch connections. Field cutting into piping will not be permitted. Spring wyes into existing line and encase entire wye, plus 6" overlap, with not less than 6" of 4,000 psi 28-day compressive strength concrete.
C. Take care while making tap connections to prevent concrete or debris from entering existing piping or structure. Remove debris, concrete, or other extraneous material which may accumulate.

3.5 BACKFILLING:
A. Conduct backfilling operations of open-cut trenches closely following laying, jointing, and bedding or pipe, and after initial inspection and testing are completed.

3.6 FIELD QUALITY CONTROL:
A. Testing Agency: The Owner will employ and pay a qualified independent testing agency to perform field quality-control testing services specified in this section. Retesting of materials failing to meet specified requirements shall be done at Contractor’s expense.
B. Testing: Perform testing of completed piping in accordance with local authorities having jurisdiction.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes storm drainage outside the building.
B. Related Sections include the following:
   1. Refer to Division-2 Section "Earthwork" for excavation and backfill required for storm drainage systems; not work of this section.
   2. Refer to Division-2 sections for concrete work required for storm drainage systems; not work of this section.
   3. Refer to Division-22 section "Plumbing Piping" for interior building systems including connections to roof and deck drains; not work of this section.

1.3 PROJECT CONDITIONS
A. Site Information: Perform site survey, and verify existing utility locations.
B. Existing Structures: Locate existing structures and piping to be closed and abandoned.
C. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Architect not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Architect's written permission.

1.4 QUALITY ASSURANCE
A. Codes and Standards:
   1. Local Regulations: Comply with governing regulations and standards of local City having jurisdiction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Stormwater Disposal Systems:
      a. Advanced Drainage Systems, Inc.
      b. Cultec, Inc.
      c. Hancor, Inc.
      d. Infiltrator Systems, Inc.
      e. PSA, Inc.

2.2 PIPES AND FITTINGS
A. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated.
B. Corrugated PE Drainage Tubing and Fittings: AASHTO M 252, Type S, with smooth waterway for coupling joints.
   1. Soiltight Couplings: AASHTO M 252, corrugated, matching tube and fittings to
C. Corrugated PE Pipe and Fittings: AASHTO M 294, Type S, with smooth waterway for coupling joints.
   1. Soiltight Couplings: AASHTO M 294, corrugated, matching pipe and fittings to form soiltight joints.

D. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M), Class III, Wall B, for gasketed joints.

E. Polyvinyl Chloride (PVC) Sewer Pipe: ASTM D 3034, Type PSM, SDR 35.
   1. Fittings: ASTM 3034, bell and spigot joints. 12” diameter and smaller.

2.3 MANHOLES
A. Provide precast reinforced concrete storm drain manholes as indicated, complying with ASTM C 478.
   1. Top: Precast concrete, of concentric cone, eccentric cone, or flat slab top type, as indicated.
   2. Base: Precast concrete, with base riser section and separate base slab, or base riser section with integral floor, as indicated.
   3. Steps: Ductile-iron or aluminum, integrally cast into manhole sidewalls.
   4. Frame and Cover: Ductile-iron, 21-3/4” diameter cover, heavy-duty, indented top design, with lettering cast into top reading "STORM SEWER", conforming to ASTM A-48, unless otherwise specified on the plans.

2.4 CATCH BASINS
A. Precast or cast in place reinforced concrete catch basins as indicated.
   1. Basin: Precast or cast in place reinforced concrete, flat slab top.
   2. Frame and Grate: Ductile-iron or galvanized steel grate, heavy-duty, bicycle proof.

2.5 PIPE OUTLETS
A. Head Walls: Amcor CP190 Precast Flared End Section or Equivalent.
B. Riprap Basins: Broken, irregular size and shape, graded stone.
   1. Average Size: NSA No. R-5, screen opening 5 inches (127 mm).

PART 3 - EXECUTION
3.1 EARTHWORK
A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.2 INSTALLATION, GENERAL
A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical.
B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line, and pull past each joint as it is completed.
C. Use manholes for changes in direction, unless fittings are indicated. Use fittings for
branch connections, unless direct tap into existing sewer is indicated.

D. Install gravity-flow piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.
   1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.

3.3 PIPE JOINT CONSTRUCTION AND INSTALLATION
A. General: Join and install pipe and fittings according to installations indicated.
B. PE Pipe and Fittings: As follows:
   1. Join pipe, tubing, and fittings with couplings for soil tight joints according to manufacturer's written instructions.
   2. Install according to ASTM D 2321 and manufacturer's written instructions.
   3. Install corrugated piping according to the Corrugated Polyethylene Pipe Association's "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
C. Concrete Pipe and Fittings: Install according to ACPA's "Concrete Pipe Installation Manual." Use the following seals:

3.4 MANHOLE INSTALLATION
A. General: Install manholes, complete with appurtenances and accessories indicated.
B. Form continuous concrete channels and benches between inlets and outlet.
C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, unless otherwise indicated.
D. Install precast concrete manhole sections with gaskets according to ASTM C 891.

3.5 CATCH-BASIN INSTALLATION
A. Construct catch basins to sizes and shapes indicated.
B. Set frames and grates to elevations indicated.

3.6 STORM DRAINAGE OUTLET INSTALLATION
A. Construct riprap of broken stone, as indicated.
B. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

3.7 DRAIN INSTALLATION
A. Install type of drains in locations indicated.
B. Fasten grates to drains if indicated.
C. Set drain frames and covers with tops flush with pavement surface.

3.8 FIELD QUALITY CONTROL
A. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed.
   1. In large, accessible piping, brushes and brooms may be used for cleaning.
   2. Place plug in end of incomplete piping at end of day and when work stops.
   3. Flush piping between manholes and other structures to remove collected debris.
B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.
1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
   a. Alignment: Less than full diameter of inside of pipe is visible between structures.
   b. Crushed, broken, cracked, or otherwise damaged piping.
   c. Infiltration: Water leakage into piping.
   d. Exfiltration: Water leakage from or around piping.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

END OF SECTION
SECTION 32 1813
SYNTHETIC GRASS SURFACING

PART 1 GENERAL

1.01 SUMMARY
   A. The Owner reserves the right to serve as the sole authority in selecting the system to be installed and in selecting the installation subcontractor. The Owner may waive specification requirements upon review of the submittal packages, bid cost, reference information and proposed schedule.

1.02 SECTION INCLUDES
   A. Furnishing all required labor, materials, equipment, and supplies necessary for installing synthetic turf inside the track oval, as shown on the plans.
   B. Synthetic grass surfacing and infill.
   C. Correction of grades and subgrade.
   D. Field graphics.

1.03 REFERENCE STANDARDS
   C. ASTM D5034 - Standard Test Method of Breaking Strength and Elongation of Textile Fabrics (Grab Test); Current Edition.
   O. CEN EN 1177 - Impact attenuating playground surfacing - Methods of test for determination of impact attenuation; Current Edition.

1.04 SUBMITTALS
   A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Submit with bid resumes of both the Project Manager and Turf Installation Foreman that will be on the project.

C. Submit with bid a list of ten (10) installations completed over the past five (5) years. The list shall include the name and phone number of a contact for each project. Contacts cannot be current or former employees of the Bidder.

D. Submit with bid detailed specifications and other descriptive literature as well as a product sample (minimum 10 in. by 10 in.) showing the turf and infill as it will appear when installed. Include the Turf Information form at the end of this section. Provide with bid submittal (2) two samples packs of all turf colors.

E. Submit with bid proposal the source of the fiber used for the turf. Provide fiber supplier’s company name, location and contact name for follow-up verification on fiber suppliers company letter head. Failure to do so will be grounds for dismissal and will be considered a non-responsive bid.

F. Submit with bid shop drawings showing field layout (delineating which markings are tufted or cut in), seaming plan, and edge/nailer detail.

G. Upon completion, Bidder shall submit two (2) copies of all product information, test results, warranty documents and maintenance information.

H. Submit with bid a warranty that shall be provided by a single source, for a minimum period of eight (8) years. A copy of the warranty shall be submitted with the bid. Specify what portion of the warranty is bonded. Warranties shall include the following:
   1. Complete replacement coverage (not prorated).
   2. Coverage shall include materials and workmanship.
   3. Removal and disposal of failed system.
   4. Replacement of failed system will be of equal quality, value and performance.
   5. Warranty shall include the coverage of the Discus event to be held on the field.
   6. Repair or replace portions that are no longer serviceable including materials, labor, and related costs.
   7. Insured by third-party. The third-party insurance policy shall submit in writing that a, non-cancelable and pre-paid policy, is in effect covering this installation, and underwritten by a Best “A” Rated Insurance Carrier. Insurance carrier must confirm that premium is paid in full and the policy is in force prior to final acceptance of the project.
   8. No deductibles or additional cost shall apply to owner due to failure.
   9. The owner reserves the right to request a change to upgrade at additional cost for any changes in design, new technology or system components.
   10. A copy of any fiber or turf component manufactures warranty shall be provided that lists all conditions, exclusions and limitations of the finished product and circumstances that can void the system warranty.
   11. At a minimum of forty-five (45) days prior to the expiration of the warranty, the warranty provider is required to schedule a walkthrough of the field. If this meeting does not occur as stated, the warranty period will be extended and not expire until the said walkthrough takes place and then end at forty-five (45) days after the walkthrough date.
   12. This warranty shall include in writing the performance of any alternative infill as well as specific maintenance requirements.

1.05 QUALITY ASSURANCE

A. Maintain one copy of the latest edition of ASTM F1487 and CPSC Pub. No. 325 at project site.

B. The Bidder shall meet the following criteria.
   1. The Bidder must have been in business for at least ten (10) years actively selling and installing infill synthetic turf.
   2. The Bidder must have installed at least ten (10) similar projects in the last five (5) years, each of at least 50,000 sq. ft. (See SUBMITTALS.)

C. The Installer shall meet the following criteria:
1. Company shall specialize in performing the work of this section. The contractor shall provide competent workmen skilled in the specific type of synthetic grass installation.
2. The designated Supervisory Personnel on the project shall be certified, in writing by the turf manufacturer, as competent in the installation of specified monofilament material, including sewing seams and proper installation of the infill mixture.
3. Installer shall be certified by the manufacturer and licensed.
4. The installer supervisor shall have a minimum of 5 years experience as either a construction manager or a supervisor of synthetic turf installations.
5. Installer must be located within 100 mile radius of project site.

D. The Owner or Owner’s representative shall have access to the project at all times and have the opportunity to inspect workmanship and materials. The Owner shall have the right to reject, or require the correction of, materials or workmanship which fails to meet specifications. Rejected or faulty work shall be repaired at no cost to the Owner, and rejected materials shall be removed from the site.

E. Impact attenuation (H.I.C.) will be tested in accordance with CEN EN 1177. With a minimum value of 1.3m.

F. Synthetic materials shall be verified / compare by the Owner/Architect using an onsite submitted sample at the time of installation to determine conformance with the Bidder’s submittal. Comparison results will be compared to the submittal from the Bidder.

G. G-max will be tested in accordance with ASTM F355. Initial G-max shall be between 90 and not exceed 130 at initial installation and shall not exceed 165 during the warranty period.

PART 2 PRODUCTS

2.01 APPROVED MANUFACTURERS (ONLY AS SUB-CONTRACTORS TO A PRE-APPROVED GENERAL CONTRACTOR)
A. Astro Turf
B. FieldTurf
C. Greenfield
D. Shaw Sports Turf
E. SprinTurf

2.02 SYNTHETIC GRASS SURFACING
A. Synthetic Grass Carpet: Yarn fibers tufted through and adhered to a porous fiber backing.
   1. Primary Blades:
      a. Fibers: Monofilament.
      b. Material: Heat and UV resistant, non abrasive polyethylene.
      c. Weight: 36 ounces per square yard.
      d. Height: 2-3/8 inch (+/- 1/8") minimum, in compliance with ASTM D5823.
      e. Tuft Bind: 10 pounds-force, minimum, in compliance with ASTM D1335.
   2. Primary Backing:
      a. Provide dimensional stability.
      b. Backing Weight: 10 ounces per square yard.
   3. Secondary Backing:
      a. Saturate primary backing and lock fibers in place.
      b. Backing Weight: 20 ounces per square yard.
      c. Complete carpet (fiber, primary and secondary backings) shall drain at a minimum rate of 10 inches per hour.
   4. Grab Tear Strength: 200 pounds.
   5. Yarn Denier: 8,000 - 11,000
   6. Face Weight: Minimum 40 ounces per square yard.
   7. Permeability: 10 inches (254 mm) of water per hour, minimum.
   8. Lead Content: 100 ppm, maximum, in compliance with ASTM F2765.
   9. Roll: 15 feet (4.6 m) feet wide, minimum.
11. Field Graphics:
   a. Inlaid Marking: Synthetic grass of the same manufacturer in colors indicated on drawings.
B. Synthetic Grass Infill: 8.4 pounds per square foot to be verified by architect with information provided by installer. Information shall be number and weight of rubber infill bags received from rubber supplier.
   1. Sand/Rubber System Infill Option: Sand ballasted layer shall be washed dust free silica sand and the infill layer of Rubber shall be of granular ground SBR granules free of toxins and heavy metals.
   2. Rubber infill shall be added until no more than ½ to ¾ in. of fiber is exposed.
   3. The sand infill shall comply within the following characteristics:
      a. Average Particle size between 20 and 30 mesh [calculated based on summing the midpoint of sieve pan fractions times the % retained on given screen fractions]
      b. Average Particle shape > 0.4 on the Krumbein scale
      c. Particle structure predominantly single grain
      d. Produce < 0.4%, -50M in API crush test at 80psig

2.03 FURNISHED MATERIALS/EQUIPMENT
A. Upon completion of the turf installation, furnish 2,000 lbs. of infill material and all pieces of scrap turf selected by the owner.
B. Attic stock requirements of twenty (20) linear feet of (1) nominal roll width for each green and 10 lineal feet of each additional color used on the installation.
C. Contractor shall supply one field groomer and one sweeper. Sweeper to have a debris collection attachment that shall pick up ¼” diameter (and larger) surface debris/material, but leave infill material or have a mechanism/screen to allow the infill to fall back to the surface. The groomer shall have plastic brushes that are adjustable and shall be designed to de-compact and level the surface of the infill without damaging the field.
D. Groomer and sweeper shall be approved by the manufacturer of the turf system proposed. It is the responsibility of the bidding contractor to ensure the equipment selected within their proposal meets these requirements.
E. Acceptable manufacturers are Greensgroomer, Sportsfield Specialties and FieldTurf GroomRight.

2.04 TUFTING AND INLAYS
A. The following markings shall be inlaid or tufted (specify which for each):
   1. Football (white) - border, goal line, 5 yd. lines, shaded numbers (match graphic color), coaches box (match graphic color)
   2. Soccer (per field design drawings) - all
   3. Center logo - mascot (color to be determined)
   4. End zone letters - school name and mascot name (color to be determined)
   5. Lacrosse (per field design drawings) - boys and girls
   6. Rugby (per field design drawings) - all
   7. Two shades of green carpet are required. The field shall use alternating light and medium green carpet every 5 yards as shown on the drawings. See attached design image.
   8. See sports field layout design drawings.

PART 3 EXECUTION
3.01 SUBGRADE
A. The synthetic turf installer shall inspect the aggregate base prior to start of installation and indicate acceptance in writing. Planarity shall not vary more than ¼ in. in 10 ft. Installation of turf over the base shall not commence without written acceptance. Starting installation of the turf over the base shall indicate acceptance of the base and constitutes full acceptance of liability of base failure.
3.02 EDGE ANCHORING
   A. The perimeter shall be anchored to a nailer attached to the concrete curb. The nailer shall be installed by the turf contractor so that the height of the infill matches the top of curb.

3.03 SYNTHETIC GRASS
   A. Carpet Rolls:
      1. Turf rolls shall be installed directly over the graded and compacted stone base. Care shall be taken to avoid disturbing the base. Equipment shall be available during installation to correct the base ahead of the placement of each roll.
      2. Unroll all carpet in the same direction.
      3. Prevent seams from being located over impact mats.
      4. Allow carpet to rest for at least 4 hours after unrolling and prior to seaming.
      5. Smooth seams and edges, eliminate overlaps and gaps.
   B. Seaming:
      1. Cut: Straight, with a clean and smooth edge.
      2. Method:
         a. Sewing: 2 thread, bound seam stitch for major seams.
         b. Bonding: for minor seams, adhesive-backed, applied uniformly with complete coverage.
   C. Securing: Staple carpet to edging 1 inch (25 mm) on center.
   D. Field Graphics:

3.04 INFILL
   A. Installation of infill material shall begin immediately following turf installation. Infill material shall be spread in lifts and properly groomed to ensure uniformity of depth. Final surface texture and appearance shall be uniform and shall replicate natural turf as closely as possible. The infill material shall only be applied when the synthetic turf fabric is dry.
   B. Apply during dry weather without signs of moisture on synthetic grass.
   C. Thoroughly brush synthetic grass prior to infill installation.
   D. Apply infill uniformly in multiple lifts, brush fibers between each application.
   E. Measure depth to confirm accordance with plans.

3.05 CLEANING & COMPLETION
   A. Protect all installed work from other construction activities as installation progresses.
   B. The Contractor shall keep the area clean throughout the construction period and free from the installation process, including track surfaces.
   C. Clean surrounding areas, including track surface of excess construction materials, debris, and waste.
   D. Remove excess and waste material and dispose of off-site in accordance with requirements of authorities having jurisdiction.
   E. Any damage to existing fixtures or facilities resulting from the installation of the synthetic turf system shall be repaired to original condition at the Contractor’s expense prior to Substantial Completion and commencement of the Warranty Period.
   F. A deficiency punch list will be produced by the Architect / Owner and installer at the conclusion of the project. All installation project deficiencies shall be remedied by the Contractor prior to the issuance of a certificate of Substantial Completion.
   G. A 3rd party testing company accredited for such tests shall provide the necessary testing data to the Owner that verifies the finished field meets or exceeds the required shock attenuation. The G-max range shall be between 90 and 120 at post installation and shall not increase by more than 10% per year or be tested below 90 or exceed 165 (or the current ASTM standard for safety) for the life of the warranty, as determined by the ASTM F355A and ASTM F1936 test
procedures. H.I.C. shall be tested in accordance with CEN EN 1177 Any documented 3rd party test results that do not meet the requirements of this specification shall be corrected by the Contractor.

H. Upon completion of the field installation, the contractor shall have an approved turf provider representative perform an on-field training maintenance seminar with the Owner. The seminar shall include a demonstration of how to use and care for the field with the provided groomer/sweeper. The assembly of the equipment will be the responsibility of the contractor. Seminar to address the use of the sweeper and groomer, review the entire provided maintenance manual (including the proper procedure for removal of gum and other debris), warranty requirements and answer any questions.

3.06 PROTECTION

A. Protect installed products until Date of Substantial Completion.
B. Restore adjacent existing areas that have been damaged by work of this section.

3.07 TURF MAINTENANCE CONTRACT (BID ALTERNATE PER FIELD)

A. Turf contractor shall provide two maintenance service visit per year for the minimum 8-year warranty as part of this proposal. Each maintenance service visit shall include at least the following minimum items:

1. Overall inspection of the field, including fiber wear analysis highlighting any high wear concerns, fiber matting or crushing, amount of loose fibers, ultraviolet degradation, infill depth and consistency, infill migration, field edging attachments including covers and in ground equipment, sewn and glued seams, line verification and field inserts (inlays).

2. Minor repairs (sewing/adhesive failures, inlay separation, loose corners and edges and general workmanship) as needed, of items found while inspecting or providing the required grooming session.

3. Grooming session including:
   a. A general sweeping and cleaning to remove foreign objects such as leaves, bird droppings, gum and other debris that may collect on the field surface.
   b. A deep groom, sweep and rejuvenation to de-compact infill to maintain appropriate G-Max levels.
   c. Add necessary infill to maintain proper infill depth.

4. Submit a written report summarizing the maintenance visit and highlight the following:
   a. General field condition overall and highlighting high wear areas to be watched between maintenance service visits.
   b. Infill condition and depth
   c. Report on repairs made including locations
SPORTS FIELD TURF RENOVATION SUBMITTAL

ALL SYNTHETIC TURF BIDDERS SHALL SUPPLY THE FOLLOWING INFORMATION

COMPANY NAME _____________________________________________________________

CONTACT INFORMATION ____________________________________________________

__________________________________________________________________________

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END OF SECTION
SECTION 32 1816.13
PLAYGROUND PROTECTIVE SURFACING

PART 2 PRODUCTS

1.01 PERFORMANCE CRITERIA

A. Because the safety of the playground depends on strict compliance with the performance criteria, this information is provided for Contractor's information.

1. The top elevation of the protective surfacing is intended to be flush with adjacent grades.

2. Use Zone: The protective surfacing has been designed to provide acceptable impact attenuation as defined in ASTM F1292 for Critical Height of ____ feet (____ m).

1.02 MATERIALS

END OF SECTION
SECTION 32 3113
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Posts, rails, and frames.
B. Wire fabric.
C. Concrete.
D. Manual gates with related hardware.
E. Accessories.

1.02 REFERENCE STANDARDS
A. ACI 301 - Specifications for Structural Concrete; 2016.

1.03 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: Provide data on fabric, posts, accessories, fittings and hardware.
C. Shop Drawings: Show locations, details, materials, dimensions, sizes, weights, finishes, operational clearances, and installation of components. See CLFMI CLF-SFR0111 for planning and design recommendations.

PART 2 PRODUCTS

2.01 MATERIALS
A. Posts, Rails, and Frames: Comply with the following:
   1. Line, Terminal, Corner, Rail, Brace, and Gate Posts: Type I round.
      a. Type I Round: LG 40 or Schedule 40 galvanized steel pipe complying with ASTM F1083. Comply with ASTM F1043, Material Design Group IA, external and internal coating Type A, consisting of not less than 1.8-oz./sq. ft. zinc; and line, end, corner, and pull posts and top rail per requirements.
      b. Post Brace Rails: Match top rail for coating and strength and stiffness requirements. Provide brace rail with truss rod assembly for each gate, end, and pull post. Provide two brace rails extending in opposing directions, each with truss rod assembly for each corner post and for pull posts. Provide rail ends and clamps for attaching rails to posts.
   2. Comply with CLFMI CLF-PM0610.
B. Wire Fabric: Comply with CLFMI's "Product Manual":
   1. ASTM A392 zinc coated applied to steel wire mesh fabric after weaving with Class 1.
      1.2-oz./sq. ft. minimum coating weight.
   2. Comply with CLFMI CLF-PM0610.
C. Cast-in-Place Concrete: Normal-weight concrete air entrained with not less than 3,000-psi compressive strength (28 days), 3-inch slump, and 1-inch maximum size aggregate:
   1. Cast-in-Place concrete complying with ACI 301.
   2. Materials consisting of Portland Cement complying with ASTM C150/C150M.
   3. Aggregates complying with ASTM C33/C33M.
   4. Potable water.

2.02 COMPONENTS
   A. Line Posts: 1.9 inch (48 mm) diameter spaced at 8 feet.
   B. Corner and Terminal Posts: 2.38 inch (60 mm) diameter.
   C. Gate Posts: 3-1/2 inch (89 mm) diameter.
   D. Top and Brace Rail: 1.66 inch (42 mm) diameter, plain end, sleeve coupled. Swedged-end or fabricated for expansion-type coupling.
   E. Gate Frame: 1.66 inch (42 mm) diameter for welded fabrication.
   F. Fabric: 2 inch (51 mm) diamond mesh interwoven wire, 7 guage thick, top selvage knuckle end closed, bottom selvage knuckle end closed.
   H. Tie Wire: Aluminum alloy steel wire.

2.03 MANUAL GATES AND RELATED HARDWARE
   A. Comply with ASTM F900 for single gates, made from galvanized steel pipe and tubing complying with ASTM F1043, complete with hardware.
      1. Hardware for Single Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches (1,525 mm) high, 3 for taller gates; fork latch with gravity drop and padlock hasp; keeper to hold gate in fully open position.
      2. Frames and Bracing: For gate fabric height 6 feet or less with welded corners.
      3. Gate Posts: Fabricate members from round galvanized steel pipe for the following gate fabric heights by leaf widths: 6 feet or less by 4 feet or less.
   B. Hardware for Double Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches (1,525 mm) high, 3 for taller gates; drop bolt on inactive leaf engaging socket stop set in concrete, active leaf latched to inactive leaf preventing raising of drop bolt, padlock hasp; keepers to hold gate in fully open position.

2.04 ACCESSORIES
   A. Caps: Cast steel galvanized; sized to post diameter, set screw retainer.
   B. Privacy Slats: Vinyl strips, sized to fit fabric weave.

PART 3 EXECUTION

3.01 INSTALLATION
   A. General Installation: Install framework, fabric, accessories and gates in accordance with ASTM F567. Do not begin installation before final grading is completed, unless otherwise permitted by Architect.
   B. Corner, Gate and Terminal Post Footing Depth Below Finish Grade: ASTM F567.
   C. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
   D. Post Setting: Hand-excavate holes for post foundations in firm, undisturbed or compacted soil. Set terminal and gate posts plumb, in concrete footings with top of footing 2 inches above finish grade. Slope top of concrete for water runoff. Protect portion of posts aboveground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Using mechanical devices to set posts per ASTM F567 is not permitted. Verify that posts are set
plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured.

E. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment.

F. Line Posts: Space line posts uniformly at 8 feet O.C.

G. Intermediate Rails: Install in one piece at post-height center span, spanning between posts, using fittings, special offset fittings, and accessories.

H. Chain-Link Fabric: Place fabric on outside of posts and rails.
   1. Position bottom of fabric 2 inches (50 mm) above concrete mowstrip.
   2. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 15 inches (380 mm) on centers.
   3. Do not stretch fabric until concrete foundation has cured 28 days.
   4. Install bottom tension wire stretched taut between terminal posts.

I. Tie Wires: Attach wire to chain-link fabric per ASTM F626. Tie fabric to line posts at maximum interval of 12 inches o.c. and to braces at maximum interval of 24 inches o.c.

J. Set terminal and gate posts plumb, in concrete footings with top of footing 2 inches above finish grade. Slope top of concrete for water runoff.

K. Line Post Footing Depth Below Finish Grade: ASTM F567.

L. Corner, Gate and Terminal Post Footing Depth Below Finish Grade: ASTM F567.

M. Brace each gate and corner post to adjacent line post with horizontal center brace rail. Install brace rail one bay from end and gate posts.

N. Do not stretch fabric until concrete foundation has cured 28 days.

O. Position bottom of fabric 2 inches (50 mm) above concrete mowstrip.

P. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.

Q. Do not attach the hinged side of gate to building wall; provide gate posts.

END OF SECTION
SECTION 32 3119
DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Decorative steel fences.

1.02 WORK INCLUDED
A. The contractor shall provide all labor, materials and appurtenances necessary for installation of the welded ornamental steel fence system defined herein at Ellis Elementary.

1.03 RELATED REQUIREMENTS
A. Section 03 3000 - Cast-in-Place Concrete.
B. Section 32 1313 - Concrete Paving.

1.04 SYSTEM DESCRIPTION
A. The manufacturer shall supply a total fence system of Montage II® Welded and Rackable (ATF – All Terrain Flexibility) Ornamental Steel Majestic™ design. The system shall include all components (i.e., panels, posts, gates and hardware) required.

1.05 REFERENCE STANDARDS

1.06 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. The manufacturer’s literature shall be submitted prior to installation.
C. Shop Drawings:
   1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
D. Manufacturer's Warranty.

1.07 QUALITY ASSURANCE
A. The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.
1.08 DELIVERY, STORAGE AND HANDLING
   A. Upon receipt at the job site, all materials shall be checked to ensure that no damage occurred during shipping or handling. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and to protect against damage, weather, vandalism and theft.

1.09 WARRANTY
   A. All structural fence components (i.e. rails, pickets, and posts) shall be warranted within specified limitations, by the manufacturer for a period of 20 years from date of original purchase. Warranty shall cover any defects in material finish, including cracking, peeling, chipping, blistering or corroding.
   B. Reimbursement for labor necessary to restore or replace components that have been found to be defective under the terms of manufactures warranty shall be guaranteed for five (5) years from date of original purchase.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. The fence system shall conform to Montage II® Welded and Rackable (ATF – All Terrain Flexibility) Ornamental Steel Majestic™ design, extended picket bottom rail treatment, 2-Rail style manufactured by Ameristar Fence Products, Inc., in Tulsa, Oklahoma.

2.02 MATERIAL
   A. Steel material for fence panels and posts shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 psi (310 MPa) and a minimum zinc (hot-dip galvanized) coating weight of 0.90 oz/ft2 (276 g/m2), Coating Designation G-90.
   B. Material for pickets shall be 1” square x 14 Ga. tubing. The rails shall be steel channel, 1.75” x 1.75” x .105”. Picket holes in the rail shall be spaced 4.715” o.c. Fence posts and gate posts shall meet the minimum size requirements of Table 1.

2.03 FABRICATION
   A. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.
   B. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail intersection by Ameristar’s proprietary fusion welding process, thus completing the rigid panel assembly (Note: The process produces a virtually seamless, spatter-free good-neighbor appearance, equally attractive from either side of the panel).
   C. The manufactured panels and posts shall be subjected to an inline electrodeposition coating (E-Coat) process consisting of a multi-stage pretreatment/wash, followed by a duplex application of an epoxy primer and an acrylic topcoat. The minimum cumulative coating thickness of epoxy and acrylic shall be 2 mils (0.058 mm). The color shall be Black. The coated panels and posts shall be capable of meeting the performance requirements for each quality characteristic shown in Table 2 (Note: The requirements in Table 2 meet or exceed the coating performance criteria of ASTM F2408).
   D. The manufactured fence system shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for Industrial weight fences under ASTM F2408.
   E. Swing gates shall be fabricated using 1.75” x 14ga Forerunner double channel rail, 2” sq. x 12ga. gate ends, and 1” sq. x 14ga. pickets. Gates that exceed 6’ in width will have a 1.75” sq. x 14ga. intermediate upright. All rail and upright intersections shall be joined by welding. All picket and rail intersections shall also be joined by welding. Gusset plates will be welded at each upright to rail intersection. Cable kits will be provided for additional trussing for all gates leaves over 6’.
   F. Pedestrian swing gates shall be self-closing, having a gate leaf no larger than 48” width. Integrated hinge-closer set (2 qty) shall be ADA compliant that shall include a variable speed and final snap adjustment with compact design (no greater than 5” x 6” footprint). Hinge-closer
set (2 qty) shall be tested to a minimum of 500,000 cycles and capable of self-closing gates up to a maximum gate weight of 260 lbs. and maximum weight load capacity of 1,500 lbs. Hinge-closer device shall be externally mounted with tamper-resistant security fasteners, with full range of adjustability, horizontal (.5" - 1.375") and vertical (0 - .5"). Maintenance free hinge-closer set shall be tested to operate in temperatures of negative 20 F to 200 F degrees, and swings to negative 2 degrees to ensure reliable final lock engagement.

PART 3 EXECUTION

3.01 PREPARATION

A. All new installation shall be laid out by the contractor in accordance with the construction plans.

3.02 INSTALLATION

A. Fence post shall be spaced according to Table 3, plus or minus ½". For installations that must be raked to follow sloping grades, the post spacing dimension must be measured along the grade. Fence panels shall be attached to posts with brackets supplied by the manufacturer. Posts shall be set in concrete footers having a minimum depth of 36" (Note: In some cases, local restrictions of freezing weather conditions may require a greater depth). The "Earthwork" and "Concrete" sections of this specification shall govern material requirements for the concrete footer. Posts setting by other methods such as plated posts or grouted core-drilled footers are permissible only if shown by engineering analysis to be sufficient in strength for the intended application.

3.03 FENCE INSTALLATION MAINTENANCE

A. When cutting/drilling rails or posts adhere to the following steps to seal the exposed steel surfaces; 1) Remove all metal shavings from cut area. 2) Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry. 3) Apply 2 coats of custom finish paint matching fence color. Failure to seal exposed surfaces per steps 1-3 above will negate warranty. Ameristar spray cans or paint pens shall be used to prime and finish exposed surfaces; it is recommended that paint pens be used to prevent overspray. Use of non-Ameristar parts or components will negate the manufacturer’s warranty.

3.04 GATE INSTALLATION

A. Gate posts shall be spaced according to the manufacturers’ gate drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected. Type and quantity of gate hinges shall be based on the application; weight, height, and number of gate cycles. The manufacturers’ gate drawings shall identify the necessary gate hardware required for the application. Gate hardware shall be provided by the manufacturer of the gate and shall be installed per manufacturer’s recommendations.

3.05 CLEANING

A. The contractor shall clean the jobsite of excess materials; post-hole excavations shall be scattered uniformly away from posts.

3.06 TABLE 1 - MINIMUM SIZES FOR MONTAGE II POSTS

<table>
<thead>
<tr>
<th>Fence Posts</th>
<th>Panel Height</th>
<th>Gate Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2&quot; x 12 Ga.</td>
<td>Up to &amp; Including 6' Height</td>
<td>Over 6' Up to &amp; Including 8' Height</td>
</tr>
<tr>
<td>3&quot; x 12 Ga.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gate Leaf</th>
<th>Up to &amp; Including 4'</th>
<th>Over 4' Up to &amp; Including 6'</th>
<th>Over 6' Up to &amp; Including 8'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 4'</td>
<td>2-1/2&quot; x 12 Ga.</td>
<td>3&quot; x 12 Ga.</td>
<td>3&quot; x 12 Ga.</td>
</tr>
<tr>
<td>4'1&quot; to 6'</td>
<td>3&quot; x 12 Ga.</td>
<td>4&quot; x 11 Ga.</td>
<td>4&quot; x 11 Ga.</td>
</tr>
<tr>
<td>6'1&quot; to 8'</td>
<td>3&quot; x 12 Ga.</td>
<td>4&quot; x 11 Ga.</td>
<td>6&quot; x 3/16&quot;</td>
</tr>
<tr>
<td>8'1&quot; to 10'</td>
<td>4&quot; x 11 Ga.</td>
<td>6&quot; x 3/16&quot;</td>
<td>6&quot; x 3/16&quot;</td>
</tr>
<tr>
<td>10'1&quot; to 12'</td>
<td>4&quot; x 11 Ga.</td>
<td>6&quot; x 3/16&quot;</td>
<td>6&quot; x 3/16&quot;</td>
</tr>
<tr>
<td>12'1&quot; to 14'</td>
<td>4&quot; x 11 Ga.</td>
<td>6&quot; x 3/16&quot;</td>
<td>6&quot; x 3/16&quot;</td>
</tr>
</tbody>
</table>
3.07 TABLE 2 - COATING PERFORMANCE REQUIREMENTS

<table>
<thead>
<tr>
<th>Quality Characteristics</th>
<th>ASTM Test Method</th>
<th>Performance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion</td>
<td>D3359 - Method B</td>
<td>Adhesion (Retention of Coating) over 90% of test area (Tape and knife test).</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>B117, D714, &amp; D1654</td>
<td>Corrosion Resistance over 1,500 hours (Scribed per D1654; failure mode is accumulation of 1/8” coating loss from scribe or medium #8 blisters).</td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>D2794</td>
<td>Impact Resistance over 60 inch lb. (Forward impact using 0.625” ball).</td>
</tr>
<tr>
<td>Weathering Resistance</td>
<td>D822, D2244, D523 (60° Method)</td>
<td>Weathering Resistance over 1,000 hours (Failure mode is 60% loss of gloss or color variance of more than 3 delta-E color units).</td>
</tr>
</tbody>
</table>

3.08 TABLE 3 - MONTAGE II - POST SPACING BY BRACKET TYPE

<table>
<thead>
<tr>
<th>Span</th>
<th>For INVINCIBLE* 8’ Nominal (91-1/2” Rail)</th>
<th>For CLASSIC, GENESIS, &amp; MAJESTIC 8’ Nominal (95-5/8” Rail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Size</td>
<td>2-1/2” 3” 2-1/2” 3”</td>
<td>2-1 3” 2-1 3” 2-1/2” 3”</td>
</tr>
<tr>
<td>Bracket Type</td>
<td>Industrial Flat Mount (BB301)* 2.5” (BB303) 3” (BB302)</td>
<td>Industrial Universal Mount (BB301) Industrial Swivel (BB304)*</td>
</tr>
<tr>
<td>Post Settings</td>
<td>94-1/2” 95” 94-1/2” 95”</td>
<td>96” 96-1/2” 96” 96-1/2” *96” *96-1/2”</td>
</tr>
<tr>
<td>+/- 1/2” O.C.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: When using BB304 swivel brackets on either or both ends of a panel installation, care must be taken to ensure the spacing between post and adjoining pickets meets applicable codes. This will require trimming one or both ends of the panel. When using the BB301 flat mount bracket for Invincible style, rail may need to be drilled to accommodate rail to bracket attachment.

END OF SECTION
SECTION 32 3300
SITE FURNISHINGS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Pipe bollards.

1.02 RELATED REQUIREMENTS
A. Section 03 3000 - Cast-in-Place Concrete: Bollard infill and underground encasement.

1.03 REFERENCE STANDARDS
C. SSPC-PA 1 - Shop, Field, and Maintenance Painting of Steel; 2016.

1.04 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Shop Drawings: Indicate plans for each unit or groups of units, elevations with model number, overall dimensions; construction, and anchorage details.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Steel Pipe Bollards:
   1. Fabricate pipe bollards from Schedule 40 steel pipe.

2.02 BOLLARDS
A. Steel Pipe Bollards: Concrete filled steel pipe with plain shaft.
   1. Shape: Round.
   2. Diameter: 6 inches (____ mm).
   3. Height Above Grade: 48 inches (____ mm).
   4. Depth Below Grade: 48 inches (____ mm).
   6. Materials:
      c. Color: As selected by Architect from manufacturer's standard range.
   7. Mounting: In-ground.

PART 3 EXECUTION

3.01 INSTALLATION
A. Anchor bollards in concrete in formed or core-drilled holes not less than 8 inches (200 mm) deep and 3/4 inch (19 mm) greater than OD of bollard. After bollards have been inserted into holes, fill annular space surrounding bollard solidly with nonshrink, nonmetallic grout, mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch (3 mm) toward bollard.

B. Anchor bollards in place with concrete footings. Support and brace bollards in position in footing excavations until concrete has been placed and cured.

3.02 ADJUSTING AND CLEANING
A. Touchup Painting: Immediately after erection clean abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
   1. Apply by brush or spray to provide a minimum 2.0-mil 0.05-mm dry film thickness.
B. Galvanized Surfaces: Clean abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION
SECTION 32 8423
UNDERGROUND SPRINKLERS

PART 1 GENERAL

1.01 SUMMARY

A. The work covered by these specifications consists of furnishing all labor, material, equipment and supplies in performing all operations in connection with providing an irrigation system and all site work in strict accordance with provided specifications, details, and drawings.

B. Any minor items of labor and/or materials not specifically noted on the drawings or specifications; but obviously necessary for the proper completion of the work, are to be considered as incidental to and are to be included in the contract. Contractor shall note such items and present them to owner before bid opening.

C. Contractor should submit construction schedule of anticipated work time to facilitate timely visits for review of work. Such proposal shall include a projected time frame for installing the system. It should reflect, in calendar days, the anticipated time required from the day of the award to completion of the system in a fully operational mode. This schedule should reflect anticipated time for ordering and receiving all components, starting and ending times for installation, system start-up, etc.

D. It is the desire of the owner to have a fully operational system by ___________. Owner reserves the right to deduct two hundred dollars ($200) per day for work completed after the time limit expires.

1.02 SECTION INCLUDES

A. Pipe and fittings, valves, sprinkler heads, and accessories.

B. Provide automatic irrigation system design and installation for all landscaped area providing adequate watering to all trees, shrubs, perennials, groundcovers, and turf.

1.03 DEFINITION

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. Mainline Piping: Downstream from point of connection to water distribution piping to and including control valves. Piping is under water distribution system pressure.

1.04 PROJECT CONDITIONS

A. Irrigation water shall be provided by the following:
   1. Water system to be connected to existing mainline.
   2. Design pressure of the irrigation design is 95 psi.

1.05 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum water coverage:
   1. Irrigation heads in lawn areas shall be spaced 85% of the radius for rotors and 90% of the radius for spray heads.
   2. Shrubs, perennials, and groundcovers shall have adequate water applied to the root zones to ensure plant health and development.

B. The irrigation system shall provide the manufacturer's recommended minimum operation pressure to every head. The pipe system shall have sufficient pressure to overcome the losses due to friction in piping, fittings, and all other equipment. Water speed in the pipes shall not exceed 5 feet per second in the irrigation mainline and lateral piping.

C. The irrigation system shall provide the manufacturer's recommended minimum operation pressure to every irrigation head.

D. Group irrigation heads into circuits having similar hydrozone requirements.
E. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties, unless otherwise indicated:
   1. Pressure Piping: 200 psig.
   2. Circuit Piping: 150 psig.
   3. Drain Piping: 100 psig.

1.06 REFERENCE STANDARDS
B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

1.07 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: Submit technical product data and installation instructions for irrigation system materials and products.
C. Shop Drawings: Submit shop drawings or “as built” drawings for irrigation systems showing piping materials, sizes, locations, and elevations. Include details of underground structures, connections, thrust blocks, and anchoring. Show interface and spatial relationship between piping and proximate structures.
D. Operation and Maintenance Data: include in maintenance manuals specified in Division 1. Include data for the following:
   1. Provide typewritten instructions for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.
   2. Provide schedule indicating length of time each valve is required to be open to provide a determined amount of water.
   3. Submit manuals with record drawings. The manual shall also contain:
      a. Identification readable from the outside of the cover stating by whom the information was compiled.
      b. Neatly type-written index near the front of the manual, furnishing immediate information as to the location in the manual of all emergency data regarding the installation.
      c. Complete nomenclature of all replaceable parts, their part numbers, current cost, and name and address of the nearest vendor of replacement parts.
      d. Complete outline of future watering schedules and when they should be changed from the initial installation schedule. The initial schedule is calculated for a watering rate to establish lawn.
      e. Copy of all guarantees and warranties issued on the installation showing all dates of expiration.
E. Record Drawings: As installation occurs, prepare accurate record drawings of piping system to be submitted prior to final inspection that also includes:
   1. Detail and dimension changes made during construction
   2. Significant details and dimensions not shown in the approved contract documents.
   3. Field dimensioned locations of valve boxes, manual drains, control wire runs not in mainline ditch, and both ends of sleeves.
   4. Take dimensions from permanent constructed surfaces or edges located at or above finish grade.
   5. Take and record dimensions at time of installation.
F. Provide reduced copy of record drawings at half-size with color key circuits and laminate both sides with 5 mil thick or heavier plastic. Mount on 1/4 inch plywood board. Drill two 1/2 inch holes at top of board and hang on hooks in custodial room or as directed by project representative.
G. Maintenance Materials: Provide the following for Owner’s use in maintenance of project.
   1. Extra Sprinkler Heads: One of each type and size.
2. Extra Valve Box Keys: One.
3. Wrenches: One for each type head core and for removing and installing each type head.

H. Warranty Documents: Warranty documents shall be submitted to owner at the time of final inspection.
I. In order to receive credit in the Rain Bird “Maxi dollar” program the owner requires that the contractor submit copies of all invoices showing Rain Bird products purchased for the project complete with pricing and quantities.

1.08 QUALITY ASSURANCE
A. Manufacturer Qualifications: Licensed firms regularly engaged in manufacture of irrigation system products of types, materials and sizes specified, whose products have been in use in similar service.
B. Work and materials shall be in accordance with latest rules and regulations, and other applicable state or local laws. Nothing in approved Contract Documents is to be construed to permit work not conforming to these codes.
C. Pre-Installation Meeting: Schedule meeting after excavation of trenches and installation of sleeves, but prior to installation of pipe.
D. Installer Qualifications: Licensed contracting firm regularly engaged in successful installation of irrigation systems similar in size and scope of this contract. Owner reserves the right to ask for and verify references from contractors past portfolio of work before award of contract.

1.09 CODES AND STANDARDS
A. Plumbing code compliance: Comply with any applicable portions of the Utah state plumbing code pertaining to the selection of materials and the installation of irrigation systems.
B. Water purveyor compliance: Comply with requirements of purveyor supplying water to the project.
C. Any permits that are needed for the installation of construction of any work included under this contract, which are required by the authorities of jurisdiction, shall be obtained and paid for by the contractor following whatever ordinances, regulations and codes requiring the permits. If the authorities of the jurisdiction require inspection at said points of the installation, the contractor shall arrange for, and be present at, any such inspections.
D. Additional work or furnishing of materials required due to inspection by the authorities of jurisdiction shall be furnished at no cost to the owner. In the event that the specifications for this project and existing ordinances, regulations or codes are in conflict, the conflict shall be noted in writing by the contractor to the owner’s authorized representative, and any necessary changes in work shall follow an established procedure for claims for extra compensation.

1.10 CONTRACTORS USE OF PREMISES
A. Contractor is responsible for damages and interruption of all existing utilities.
B. Contractor shall not unreasonably encumber site with materials and equipment.
C. Contractor shall assume full responsibility for protection and security of materials and equipment stored on job site.
D. Contractor shall confine operations to areas within his contract limits.
E. Any damages to existing structures, surfaces, or utilities caused by contractor or contractor’s employees shall be considered contractor’s responsibility and will be part of this contract to be corrected to satisfaction of owner.
F. Contractor is responsible for contacting utility locating services and keeping utilities clearly marked on the job site. School-owned utilities and piping will be marked by school district personnel; however, contractor is responsible to contact the district maintenance department to schedule locating and must give adequate time for locating to be done. Any utilities, wiring, or piping damaged by contractor without following these guidelines will be the sole responsibility of the contractor to repair.
G. Contractor is responsible for safety on job site. Barricading or covering open trenches, eliminating trip hazards, and other safety issues are a priority. Rental or supplying of barricades is contractor’s responsibility.

1.11 PERFORMANCE BOND/BID BOND/INSURANCE
A. The owner shall have the right to require the contractor to furnish bonds covering faithful performance of the Contract and payment of obligations arising thereunder as stipulated in bidding requirements. A bid bond, certified check, or cashier’s check executed in favor of ________ School District in the amount of five percent (5%) of the total bid price must be submitted with the proposal as guarantee that bidder is willing to enter into a contract. Bidder must also be able to provide a one hundred percent (100%) Performance and Payment Bond at time of award of contract.

B. Successful contractor must meet Federal, State, County and City codes and regulations. Proof of Liability Insurance and Workmen’s Compensation must be submitted with bid.

1.12 SUPERVISION
A. The contractor shall provide a competent superintendent and any necessary assistants on the project when work is in progress. The superintendent shall not be changed during the project without the consent of the owner’s representative unless the superintendent ceases his status as an employee of the contractor. The superintendent shall represent the contractor in the contractor’s absence, and all directions given to him by the owner’s representative shall be binding as if they were given to the contractor.

B. The contractor’s superintendent shall supervise the contractor’s employees on the job site and be responsible for their actions and conduct on the job site.

1.13 GUARANTEE
A. Submit one-year written guarantee signed by underground sprinkler contractor, agreeing to repair or replace all defects in material, equipment, and workmanship.

B. Guarantee shall also cover repair of damage to any part of the premises resulting from leaks or other defects in material, equipment, and workmanship to the satisfaction of the Owner. Repairs if required, shall be done promptly at no cost to the Owner.

1.14 SEQUENCING AND SCHEDULING
A. Maintain uninterrupted water service to building during normal working hours. Arrange for temporary water shutoff with owner.

B. Coordinate lawn irrigation piping with work specified in Division 32 9223 "Sodding" and 32 9300 "Plants".

C. Coordinate lawn irrigation piping with utility work.

PART 2 PRODUCTS

2.01 IRRIGATION SYSTEM
A. Manufacturers:
   1. Rain Bird Sales, Inc; Dave Chandler (dchandler@rainbird.com): www.rainbird.com/#sle.

2.02 FILL MATERIAL
A. Backfill Material
   1. Backfill material for irrigation pipe shall consist of sand, native material or topsoil with no rocks larger than 1/4 inch in any dimension for pipe bedding haunches and initial backfill above the pipe. Above the initial backfill, the trench shall be filled with soil with no debris or rocks greater than 1-1/2 inch in any dimension. Landscape architect shall approve on-site material for backfill operation.

   2. Backfill for irrigation sleeves under pavement shall consist of granular material with no rock size larger than 1/4 inch in any dimension up to the base for the paving above the pipe.
3. Imported backfill material shall be clean soil, free from organic material, trash, debris, rubbish, broken cement, asphalt material, or other objectionable substances and approved by the Landscape Architect.

B. Drainage Fill Material
   1. Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 1-1/2 inch sieve and not more than 5% passing a No. 4 sieve.

2.03 PIPE MATERIALS

A. PVC Pipe: ASTM D2241; 200 psi (1.38 MPa) pressure rated upstream from controls, 160 psi (1.10 MPa) downstream; solvent welded sockets.
   1. All lateral piping smaller than 3", shall be schedule 40 pressure rated PVC glue joint pipe with ratings printed on outside of pipe.
   2. All main line pipe 3" and larger shall be class 200 pressure rated PVC gasket joint pipe with ratings printed on outside of pipe, unless otherwise noted on drawings or details.
   3. All lateral pipe and fittings shall be schedule 40 pressure rated PVC unless specifically noted on drawings.
   4. All main pressure side valve manifold piping shall be domestic galvanized iron pipe and fittings. All galvanized iron pipe and fitting configurations shall match detail drawings exactly.

B. Polyethylene Pipe:
   1. Pipe shall be continuously and permanently marked with Manufacturer's name, size, schedule, type, and working pressure.
   2. All irrigation lateral piping shall be polyethylene plastic pipe ID controlled PE 3408, ASTM 2239.

C. Fittings:
   1. Mainlines shall have PVC sch. 40 fittings for pipe sizes 3/4 inch through 1-1/2 inch, PVC sch. 80 for pipe sizes 2 inch through 3 inch and push on ductile or mechanical cast iron fittings on PVC mainline 4 inch and larger.
   2. Main line pressure fittings shall be cast iron manufactured by Harco or approved equal.
   3. All polyethylene pipe fittings shall be compression fittings or insert barbed fittings secured with stainless steel clamps.
   4. Remote control valve connection to mainline shall be PVC SST tee, epoxy coated double strap saddle, M.J. tee, or Harco Ductile Irons Service tees.
   5. Joint restraint shall be Leemco or approved equal.

D. Sleeve Material:
   1. Sleeve diameter shall be two times larger than pipe that is to be installed in sleeve.
      Sleeves 4" and smaller diameter shall be PVC schedule 40. Sleeves 4 inch and larger shall be Class 200 PVC or PVC sewer pipe.
   2. Piping and control wires under walks, roads, or other hard surfaces shall be installed in class 200 PVC sleeves of adequate size or as noted on drawings.
   3. Sleeves for electrical conduit shall be adequate to accommodate minimum conduit sizes as required by uniform electrical code.
   4. Wire sleeves shall be PVC pipe or electrical tubing. Maximum number of 14-gauge wire in sleeve shall be as follows:
      a. 1-10 wires in a 1 inch sleeve
      b. 11-18 wires in a 1-1/4 inch sleeve
      c. 19-25 wires in a 1-1/2" sleeve
      d. 26-40 wires in a 2" sleeve
      e. 41-56 wires in a 2-1/2" sleeve
      f. 57-88 wires in a 3" sleeve

E. Pipe Connection Material
   1. P-70 primer
   2. 711 solvent/glue
   3. Teflon tape
2.04 OUTLETS

A. Manufacturers:
   1. Rain Bird.

B. All sprinkler heads shall be the brand, model, size, and type shown on drawings.

C. All sprinkler heads shall be installed on a “swing joint” assembly. Lawn spray heads and small rotors with an inlet size 3/4” and smaller shall be installed as per manufacturer’s recommendations with “funny pipe” and “swing ells” as manufactured by Rain Bird or approved equal. All large stream rotor and impact heads shall be installed with three 1” schedule 40 marlex street ells and one schedule 80 1”X12” nipple. Prefabricated swing joint assemblies by Spears Manufacturing or other approved equal can be substituted if desired. All “swing joint” configurations shall match detail drawings exactly.

D. Rotary Type Sprinkler Head: Pop-up type with screens; fully adjustable for flow and pressure; size as indicated; with letter or symbol designating degree of arc and arrow indicating center of spray pattern.
   1. Rain Bird Rotary Heads: RVAN 1724, rotary nozzles, and 5000 MPR.
   2. Rain Bird Rotors: 3500, 5000, 6504, and 8005.

E. Spray Type Sprinkler Head: Pop-Up head with full circle pattern or head per plan.

F. Quick Coupler & Hose Bibs:
   1. Rainbird 44NP on secondary water systems or 44LRC on culinary water systems or approved equal with corresponding 2049 unlock key and 44K valve key.

G. Risers: Stationary spray pop-up sprinkler heads, shrub spray heads, stationary spray sprinkler heads and rotor heads shall have risers made up of one of the following ways:
   1. Risers for irrigation heads with inlet size of 1/2 inch shall be swing pipe 14 inches long minimum and 24 inches maximum. Swing pipe with spiral barb fittings and street “L” shall be assembled according to plan details. Equal as approved by landscape architect before bidding.
   2. Riser for irrigation heads with 3/4 inch to 1 inch inlets shall have a swing joint assembly according to details on drawing.

2.05 VALVES

A. Manufacturers:
   1. Rain Bird.
   2. Carson
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. All control/master valve/quick coupler valves

C. Gate Valves: Bronze construction non-rising stem.
   1. NIBCO or CLOW or Matco-Norca non-rising stem, resilient wedge, gate valve, or approved equal. Bronze construction, designed for working pressure of 150 PSI minimum.
   2. Valves sized two and a half (2-1/2) inches and larger shall have flanged connections. Valves two inches and smaller shall have threaded connections with unions on each side of the valve.
   3. Buried valves shall have cross handles or 2” square nut designed to receive operating key. Valves inside structures or vaults shall have wheel handles.

D. Remote Control Valves:
   1. All control valves used shall be scrubber valves.
   2. Rain Bird PESB-R PRS-D with pressure regulation, scrubber screens and purple handle for reclaimed water.

E. Valve Box and Cover: all boxes to have locking lids.
   1. Valves in large areas or in groups of three or more are located in pre-cast concrete valve boxes. Check with owner and drawings for locations and details.
2. Control valve boxes shall be appropriate size, made of HDPE plastic, green in color, with bolt down lid. Valve boxes shall be made by Carson Industries or approved equal. No more than one valve shall be located in each plastic box.

3. Valves located in hard surface areas shall be housed in a cast iron 3-piece adjustable extension box.

4. Circuit or Isolation valve: Carson 1220 jumbo box or approved equal.

5. Valve box supports: standard size fired clay paving bricks without holes.

F. Drain Valves:
   1. Nibco Brass Ball Gas Cock with Teflon seat or approved equal. Brass ball valve shall have “T” handle on main lines and shall be in valve boxes on lateral lines.
   2. Ford B11-444 NLFemale pipe thread with no lead alloys. Ball valve shall have “T” handle on main lines and shall be in valve boxes on lateral lines.

G. Stop & Waste Valve:
   1. 2" Mueller Mark II Oriseal.

H. Master Valve:
   1. Master valve shall be provided with a manual-operating feature to enable valve to be opened manually or in case of power outage.
   2. Rain Bird 300 BPES Brass Master Valve.

I. Combination Air & Vacuum Relief Valve:
   1. Crispin Universal Air Valve or approved equal.
   2. Bernad Model 02-ARC-1 or approved equal.

J. Flow Sensor & Control:
   1. Rain Bird FS350-B Brass Tee Flow Sensor

2.06 CONTROLS

A. Manufacturers:
   1. Rain Bird.
   2. Substitutions: See Section 01 6000 - Product Requirements.

B. Controller: Rain Bird ESP-LXMEF commercial controller.
   1. Remote phone connection to controller.
   2. Provide any wiring, communication, links computer programs to make weather station and controller operational.

C. Controller Housing: NEMA 250 Type 3; weatherproof, watertight, with lockable access door.

D. Wire Conductors:
   1. Electrical Wire:
      a. All wiring shall conform to the National Electrical Code.
   2. Traditional Wiring:
      a. Control wire shall be UL listed direct burial cable not smaller than 14 gauge. In some cases 18-gauge multi-strand wire is used in special situations as shown on drawings and approved by owner.
      b. Maxicom communication and flow sensor wire to shall be a three pair shielded cable specified by Rain Bird. Wire must be PE-39 cable as supplied by a Rain Bird Distributor.
      c. Add extra wires as shown on drawings for future use. Wire shall be of a different color or marked as an extra wire.
      d. Colors of wire shall be as follows:
         1) Control wire for turf areas: Red
         2) Control wire for shrub areas: Yellow
         3) Control wire to master valve: Blue
         4) Control wire to filter blowout valve: Brown
         5) Common wire: White
         6) Extra wires: Orange
3. Expansion Curls: shall be provided within three (3) feet of each wire connection to solenoid and at least every three hundred (300) feet in length. (Expansion curls are formed by wrapping 36" of wire around a rod or pipe 1" or more in diameter, then withdrawing the rod for single strand wire and loosely coiled for two wire cable).

2.07 OTHER COMPONENTS
A. Mixes: Concrete for thrust blocks on irrigation pipe 3" or larger.
   1. One cu. ft. cement, 2 cu. ft. sand, 4 cu. ft. gravel, and 5 gallons minimum to 6 gallons maximum water.
   2. Mix thoroughly before placing.
B. Submit other components recommended by Manufacturer for Architect’s review and acceptance prior to installation.
C. Provide components necessary to complete and make system operational.
D. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
   1. Two valve box cover keys.
   2. Two quick coupler keys with brass hose swivel.
   3. Two manual drain valve keys.
   4. Two sets of sprinkler wrenches for adjusting, cleaning or disassembly of each type of sprinkler.
   5. Two each of any other tools required for any other equipment.

PART 3 EXECUTION
3.01 OWNERS SALVAGE RIGHTS
A. Any items removed and not reused in contract will remain owner’s property and will be returned to owner at his discretion.

3.02 EXAMINATION
A. Verify location of existing utilities.
B. Verify that required utilities are available, in proper location, and ready for use.
C. Prior to installation of irrigation system, the contractor must verify the supply pressure at the work site. If there is a failure to obtain the needed pressure or if an excess pressure situation exists for normal operation, the contractor must contact the owner for any adjustments to the supply or irrigation system design. Failure to report any discrepancies in pressure due to any reason, and any installation done prior to notification of owner shall be done at the expense of the contractor.

3.03 PREPARATION
A. During construction and storage, protect materials from damage and prolonged exposure to sunlight.
B. Work damaged during course of work in this section shall be replaced or repaired at no additional cost to Owner. If damaged work is new, repair or replacement shall be performed by installer of original work.
C. Layout and stake locations of system components.
D. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system.
E. All lateral lines shall run parallel with planting areas and avoid conflict with the location of plant materials. Where trenching is required in proximity to plant materials care shall be taken to avoid damage to roots. Do not cut existing tree roots measuring over 2 inches in diameter.

3.04 TRENCHING
A. Trench Size:
   1. Minimum Cover Over Installed Supply Piping: 18 inches (457 mm).
2. Minimum Cover Over Installed Branch Piping: 12 inches (305 mm).

   B. Trench to accommodate grade changes.
   C. Maintain trenches free of debris, material, or obstructions that may damage pipe.
   D. Pulling of pipe is not permitted.
   E. When digging on project site, the area shall be “blue staked” to identify the approximate location of all known underground utilities and structures.
   F. Excavation work shall be as deep and as wide as required to safely perform the work, such as making mainline connections or forming vaults. Where trenching is done in established lawn, care must be taken to keep the trenches only as wide as is necessary to accomplish the work.
   G. If more than one line is required in a single trench, that trench shall be deep and wide enough to allow for at least 3 inches of separation between pipes. Install the piping in a manner for easy repair in the future.
   H. Over-excavate trenches 2 inches and bring back to indicated depth by filling with backfill material as specified under Part 2 - Products. Separate out rocks larger than 1-1/2 inch in any direction uncovered in trenching operation from excavated material and remove from areas to receive landscaping.
   I. Where it becomes necessary to excavate beyond the limits of normal excavation lines to remove rock or other interfering objects, the void remaining after the removal of the object shall be backfilled with suitable material and compacted as per the “Earthwork” section. The removal of all rock or other interfering objects and the backfilling of voids left by such removals shall be at the expense of the contractor.
   J. Any existing utility lines damaged during excavating or trenching shall be repaired immediately after notification of the utility owner and to his/her satisfaction. Should utility lines be encountered, which are not indicated on plans, the project representative shall be notified. The repair of any damage shall be done as soon as possible by the contractor or the utility owner and proper compensation will be negotiated by the owner. Such utility locations shall be noted on the “as-built” drawings.

3.05 INSTALLATION

   A. General:
      1. Install pipe, valves, controls, and outlets in accordance with manufacturer’s instructions.
      2. Connect to utilities.
      3. Set outlets and box covers at finish grade elevations.
      4. Provide for thermal movement of components in system.
   B. Pipes:
      1. Install pipe in manner to provide for expansion and contractions as recommended by manufacturer.
      2. Unless otherwise indicated on approved drawings, install main lines and lateral lines connecting rotor pop-up sprinklers with minimum cover of 18 inches based on finished grade. Install remaining lateral lines with minimum of 12 inches of cover based on finish grade.
      3. Install pipe and wires under driveways or parking areas in specified sleeves 18 inches minimum below finish grade or as shown on approved drawings.
      4. Slope pipes under parking areas or driveways to drain outside these areas.
      5. Locate sprinkler heads no closer than 12 inches from building foundation. Heads immediately adjacent to mow strips, walks, or curbs shall be one inch below top of mow strip, walk, or curb and have 1 to 3 inches clearance between head and mow strip, walk, or curb.
      6. Slope piping for self drainage to control box where possible.
      7. Where this is not possible, slope pipe to a minimum number of low points. Install at these low points:
         a. 3/4 inch manual drain
b. Install 2 inch class 200 PVC pipe over top of manual drain and cut at finish grade,
c. Install rubber valve cap marker flush with finished grade.
d. Do not use automatic drain valves.

8. Cut plastic pipe square. Remove burrs at cut ends prior to installation so unobstructed flow will result.

9. Make solvent weld joints as follows:
   a. Do not make solvent weld joints if ambient temperature is below 40 degrees F.
   b. Clean mating pipe and fitting with clean, dry cloth and apply one coat of P-70 primer to each.
   c. Apply uniform coat of 711 solvent to outside of pipe.
   d. Apply solvent to fitting in a similar manner.
   e. Re-apply light coat of solvent to pipe and quickly insert into fitting.
   f. Give pipe or fitting a quarter turn to ensure even distribution of solvent and make sure pipe is inserted to full depth of fitting socket.
   g. Hold in position for 15 seconds minimum or long enough to secure joint.
   h. Wipe off solvent appearing at outer shoulder of fitting.
   i. Do not use excessive amount of solvent thereby causing obstruction to form on inside of pipe.
   j. Allow joints to set at least 24 hours before applying pressure to PVC pipe.

10. Threaded connections shall be made with teflon tape.

C. Sleeving:
   1. Contractor is responsible to coordinate the installation of sleeving with the work of other trades (i.e. concrete, asphalt paving, etc.).
   2. Sleeve irrigation water lines and control wires under walks and paving. Extend sleeves 6 inches minimum beyond walk or pavement edge. Cap sleeves until pipes and wires are installed to keep sleeve clean and free of dirt and debris.
   3. Use one water pipe maximum per sleeve. Sleeve control wiring in separate sleeve.
   4. Position sleeves with respect to buildings and other obstructions so pipe can be easily removed.

D. Outlets:
   1. Use threaded nipples for risers to each outlet.
   2. Sprinkler Heads:
      a. Prior to installation of sprinkler heads, open control valves and use full head of water to flush out system.
      b. Set sprinkler heads and quick-coupling valves perpendicular to finish grade.
      c. Do not install sprinklers using side inlets. Install using base inlets only.
      d. Set sprinklers at a consistent distance from existing walks, curbs, and other paved areas and to grade.
      e. Shrub spray heads shall be installed on risers a minimum of 12 inches above finish grade of planting area where not adjacent to pedestrian areas. At shrub areas adjacent to pedestrian access use 12” pop-up spray heads.

E. Controls:
   1. Install irrigation controller per manufacturer’s recommendation and with proper grounding for surge and lightning protection.
   2. Install irrigation controller in mechanical room per drawings.

F. Valves & Valve Boxes:
   1. Install control wires, and valves in accordance with Manufacturer’s recommendations and per electrical code.
   2. Install valves, in plastic boxes with locking reinforced heavy-duty plastic covers. Locate valve box tops at finish grade. Do not install more than two valves in a single box.
   3. Place pea gravel a minimum of 6 inches deep below valve for drainage. Extend washed gravel 3 inch minimum beyond limits of valve box. Maintain 4 inch minimum between bottom of valve and top of gravel and 3 inches minimum clearance between the top of the valve to the bottom of valve cover. Set valve boxes over valve so all parts of valve can be
reached for service. Set cover of valve box even with finish grade. Valve box shall be reasonabably free from dirt and debris.

4. Install 3/4 inch brass ball valve in valve box on downstream side of automatic valves if lateral line slopes toward valve box.

5. Install quick coupling valves in appropriate locations in valve boxes.

6. Isolation valves, and any other equipment required by local authorities shall be installed according to local codes and requirements in order to make this system complete.

7. Install isolation valves, Air Release Valve, Master control Valves and Flow Sensors according to details plans and manufactures recommendations.

8. Install any other equipment required by local authorities according to local codes and requirements in order to make this system complete.

G. Wiring:

1. Standard Wire:
   a. Tape control wire to side of main line every 10 feet. Where control wire leaves main or lateral line, enclose it in Class 200 PVC conduit.
   b. Place all waterproof wire splice connectors inside valve boxes.
   c. Use white or gray color for common wire and other colors for all other wire. Each common wire may serve only one controller. Provide 12 inches of expansion loop slack wire at all connections inside valve box.
   d. Run one extra control wire from panel continuously from valve to valve throughout system like the common wire for use if the common wire fails. Wire shall be a different color than all other wires and shall be marked in control box as an extra wire. Extend extra control wires 24 inches and leave coiled in each valve box.

H. Earth Grounding:

1. Earth Grounding rod(s) or plate(s) shall provide a minimum resistance of 10 ohms or less. A minimum of one rod is required but second rod a plate or multiple rods and plates may be required if the rods or plates resistance are over 10 ohms.

2. Ground rods and plats shall be attached to ground wire by Cadweld Connection.

3. Electrical discharge areas for rods and plates are to be kept moist. Install in lawn area or provide irrigation for to maintain soil moisture as needed.

4. Install Ground Enhancement Materials if necessary, to improve soil conductivity.

5. Provide inground surge protection for irrigation controller as per details and environmental conditions.

6. Rainbird and WeatherTRAK WT2W-LSP Install in line surge protectors for two wire control systems every 500 feet or every 5 decoders which every is smallest and at the end of each two-wire path over 25'.

7. Grounding test shall be done. Tester must be approved by Weber School District. Weber School District can provide tester to be paid by the contractor.

I. After piping is installed, but before outlets are installed and backfilling commences, open valves and flush system with full head of water.

3.06 FIELD QUALITY CONTROL

A. Notify landscape architect two working days minimum prior to testing.

B. Field inspection and testing will be performed under provisions of Section 01 4000 - Quality Requirements.

C. Prior to backfilling, test system for leakage at main piping to maintain 100 psi (690 kPa) pressure for six hours minimum.

D. System is acceptable if no leakage or loss of pressure occurs and system self drains during test period.

3.07 BACKFILLING

A. Cover both top and sides of pipe with 3 inch (75 mm) of backfill material as speficied under Part 2 - Products.
B. Backfill trench and compact to within 5 inches (127 mm) of finish grade as specified in related sections. Protect piping from displacement. Top 5 inches (127 mm) of backfill shall be topsoil as specified in related section.

C. Do not cover pressure main, sprinkler pipe, or fittings until pressure test has been completed and architect has inspected and approved the system.

D. After backfilling, perform an operating test of the entire system. Operate the entire system through one cycle of the controller for the purpose of checking coverage and assuring the absence of leaks. Repair water lines, valves, or connections which show evidence of leakage.

E. All trenches shall be backfilled and then saturated with water sufficiently to ensure no settling of the surface after lawn is planted.

F. Any portion of the system which shows defects or leakage shall be repaired to the satisfaction of the landscape architect and Owner or be replaced. After all repairs or replacements have been made and approved by the landscape architect, the above required test shall be made again.

3.08 SYSTEM STARTUP

A. Prepare and start system in accordance with manufacturer's instructions.

B. Adjust control system to achieve time cycles required to provide proper amounts of water to all plants.

C. Adjust heads to proper grade when turf is sufficiently established to allow walking on it without appreciable harm. Such lowering or raising of heads shall be part of original contract with no additional cost to Owner.

D. Adjust sprinkler heads for proper distribution and so spray does not fall on building.

3.09 CLOSEOUT ACTIVITIES

A. At the point of substantial completion of work outlined in these plans, the landscape contractor shall contact the owner's representative and arrange for a walk through to verify the installation of the system. A coverage test will be completed and the system installation inspected and a punch list of final items needing completion made.

B. At the time of final inspection, the entire system must be tested in the presence of owner’s representative. It must be fully operational in a satisfactory condition, with full uniform coverage of the areas indicated to be irrigated. All heads shall be adjusted to pattern, radius, and grade level.

C. Before the inspection is complete, the contractor must furnish the “as built” drawings. These drawings should be updated on a daily basis to ensure accuracy. These drawings must show the location of all piping, valves, heads, wire splices and other pertinent information. These drawings and all maintenance manuals must be submitted at the time of final inspection in accordance with these specifications.

D. If at the time of the final inspection there is any additional work to satisfy contract requirements, it will be noted on a “punch list”. Contractor will have 10 days in order to satisfy, or make suitable arrangements with owner to satisfy items on the “punch list”. At owner’s discretion final payment or a portion thereof, could be held pending completion of “punch list” items.

E. Instruct Owner's personnel in operation and maintenance of the system, including adjusting of sprinkler heads. Use operation and maintenance data as basis for demonstration.

3.10 CLEAN-UP AND MAINTENANCE

A. Remove from site all debris resulting from work of this section.

B. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

C. Provide one complete spring start-up and a fall shutdown by installer, at no extra cost to Owner.
3.11 WARRANTY

A. All work shall be warranted for compliance with the contract requirements, including replacement, for a period of one year from date of substantial completion. If an unsatisfactory condition develops during the warranty period and is due to negligence, faulty materials, or workmanship, contractor shall immediately replace such items in a satisfactory condition. All warranties shall be in writing, signed by contractor or legal representative, and worded as approved by owner. Warranty documents shall be presented to owner at the time of final inspection.

B. During one-year warranty period, contractor will comply with the following:
   1. Fill and repair low areas and replace plantings due to settlement of excavated areas.
   2. At the end of the first watering season, contractor shall shut off and winterize the system.
   3. At the beginning of the next season, contractor shall restart system and make any repairs or adjustments needed to make system fully operational.

END OF SECTION
SECTION 32 9113
SOIL PREPARATION

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Perform soil preparation work.
B. Furnish and apply soil amendments.
C. Perform fine grading work required to prepare site for paving finish grading and for landscape finish grading.

1.02 REFERENCES

1.03 SUBMITTALS
A. Product Data: Product literature and chemical/nutrient analysis of soil amendments and fertilizers.
B. Informational Submittals:
   1. Field Quality Control Submittals:
      a. Submit tests on imported and site topsoil by licensed laboratory before use.
      1) Before use, topsoil shall meet minimum specified requirements and be approved by Architect.
      2) If necessary, submit proposed amendments and application rates necessary to bring topsoil up to minimum specified requirements.
      b. Submit report stating location of source of imported topsoil and account of recent use.

PART 2 PRODUCTS

2.01 MATERIALS
A. Topsoil:
   1. Topsoil used in landscaped areas, whether imported, stockpiled, or in place, shall be fertile, loose, friable soil meeting the following criteria:
      a. Chemical Characteristics:
         1) Acidity / alkalinity range: pH 5.5 to 8.0.
         2) Soluble Salts: less than 3.0 mmhos/cm.
         3) Sodium Absorption Ratio (SAR): less than 6.0.
         4) Organic Matter: greater than one percent.
      b. Physical Characteristics:
         1) Gradation as defined by USDA triangle of physical characteristics as measured by hydrometer.
            (a) Sand: 15 to 60 percent
            (b) Silt: 10 to 60 percent
            (c) Clay: 5 to 30 percent
         2) Clean and free from toxic minerals and chemicals, noxious weeds, rocks larger than 1-1/2 inch in any dimension, and other objectionable materials.
         3) Soil shall not contain more than 2 percent by volume of rocks measuring over 3/32 inch in largest size.
      c. Fertility Requirements:
         1) Nitrate-nitrogen ppm > 20
         2) Phosphorous ppm > 15
         3) Potassium ppm > 150
         4) Iron ppm > 10

B. Soil Amendments:
1. Incorporate following soil amendments into topsoil, either import or stockpiled, used on site. Adjust application rates and add amendments that shall bring the soil to comply with soils test:
   a. Acceptable Soil Amendments And Application Rates:
      1) Sulfur - 0.5 lbs. per 1000 sq. ft.
      2) Equal as approved by Architect before installation.
   b. Acceptable Fertilizers And Application Rates:
      1) Lawns: Phosphorus 1-2 lbs per 1000 sq. ft., Potassium 2 lbs. per 1000 sq.ft., and Nitrogen 2-4 lbs. per 1000 sq. ft.
      2) Shrubs: Phosphorus 1-2 lbs per 1000 sq. ft., Potassium 2 lbs. per 1000 sq.ft., and Nitrogen 1-2 lbs. per 1000 sq. ft.
      3) Equal as approved by Architect before installation.
   c. Acceptable Soil Conditioners And Application Rates:
      1) Type One Acceptable Products.
         (a) Soil conditioner that meets the required fertilizer and soil amendments stated above can be used at the discretion of the contractor.

PART 3 EXECUTION

3.01 PERFORMANCE

A. Protection of In-Place Conditions: Protect utilities and site elements from damage.

B. Soil Amendments:
   1. Add specified soil amendments at specified rates to lawn areas.
   2. Roto-till or otherwise mix amendments evenly into top 4 inches of topsoil.
   3. Incorporate and leach soil amendments which require leaching, such as gypsum, within such time limits that soil is sufficiently dry to allow proper application of fertilizer and soil conditioners.

C. Surface Preparation:
   1. Landscaping and Planting Areas:
      a. Before grading, dig out weeds from planting areas by their roots and remove from site. Remove rocks larger than 1-1/2 inches in size and foreign matter such as building rubble, wire, cans, sticks, concrete, etc.
      b. Before beginning maintenance period, plants shall be in at least as sound, healthy, vigorous, and in approved condition as when delivered to site, unless accepted by Architect in writing at final landscape inspection.
      c. Remove imported paving base material present in planting areas down to natural subgrade or other material acceptable to Architect.

D. Performance:
   1. Do not expose or damage existing shrub or tree roots.
   2. Tolerances:
      a. Landscaping and Planting Tolerances:
         1) Maximum variation from required grades shall be 1/10 of one foot.
         2) To allow for final finish grades of planting areas, fine grade elevations before placing topsoil and mulch are:
            (a) Sod Areas: 5.5 inches below top of walk or curb.
            (b) Planter Bed Areas: 16 inches below top of walk or curb.
      3. Do not expose or damage existing shrub or tree roots. Redistribute approved existing topsoil stored on site. Remove organic material, rocks and clods greater than 1-1/2 inch in any dimension, and other objectionable materials.
      4. Slope grade away from building as specified. Direct surface drainage in manner indicated on Drawings by molding surface to facilitate natural run-off. Fill low spots and pockets with specified fill material and grade to drain properly.

END OF SECTION
SECTION 32 9223
SODDING

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Placing topsoil.
B. Fertilizing.
C. Sod installation.
D. Maintenance.

1.02 RELATED REQUIREMENTS
A. Section 31 2200 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.

1.03 DEFINITIONS

1.04 REFERENCE STANDARDS
B. TPI (SPEC) - Guideline Specifications to Turfgrass Sodding; 2006.

1.05 QUALITY ASSURANCE
A. Sod Producer: Company specializing in sod production and harvesting with minimum five years experience, and certified by the State of Utah.
B. 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.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Deliver sod in rolls. Protect exposed roots from dehydration.
B. Do not deliver more sod than can be laid within 24 hours.
C. Harvest, deliver, store, and handle sod according to the requirements of the American Sod Producer's Association (ASPA) "Specifications for Turfgrass Sod Materials and Transplanting/Installing".

1.07 PROJECT CONDITIONS
A. Utilities: Determine location of above grade and underground utilities and perform work in a manners which will avoid damage. Hand excavate as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.
B. Excavation: When conditions detrimental to plant growth are encountered such as rubble fill, adverse drainage conditions, or obstructions, notify landscape architect before planting.

1.08 COORDINATION AND SCHEDULING
A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.

1.09 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. Special Warranty: warrant all lawn areas for a period of one year after date of substantial completion against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by owner, abnormal weather conditions unusual for warranty period, or incidents that are beyond contractor's control.

C. Remove and replace dead materials immediately unless required to plant in the succeeding planting season.

D. A limit of one replacement of each plant material will be required, except for losses or replacements due to failure to comply with requirements.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sod: TPI (SPEC), Certified Turfgrass Sod quality; cultivated grass sod; type indicated in plant schedule on Drawings; with strong fibrous root system, free of stones, burned or bare spots; containing no more than 5 weeds per 1000 sq ft (100 sq m). Minimum age of 18 months, with root development that will support its own weight without tearing, when suspended vertically by holding the upper two corners.
   1. Kentucky Blue Grass Type: 3 cultivar minimum.
   2. Thickness: "Thin" sod, minimum 1/2 inch (13 mm) and maximum 1 inch (25 mm) topsoil base.
   3. Thickness: "Thick" sod, minimum 1 inch (25 mm) and maximum 1-3/8 inch (35 mm) topsoil base.
   4. Cut sod in area not exceeding 1 sq yd (1 sq m).
   5. Machine cut sod and load on pallets in accordance with TPI (SPEC) Guidelines.

B. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay, or impurities, plants, weeds and roots; pH value of minimum 5.4 and maximum 7.0. Bring surface to specified elevation relative to walk or curb.

C. Commercial Fertilizer: Complete fertilizer of neutral character; recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, to the following proportions:
   1. Nitrogen: >16% (of which 50% will be organic). Provide nitrogen in a form that will be available to lawn during initial period of growth.
   2. Phosphoric Acid: 16%
   3. Soluble Potash: 8%

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that prepared soil base is ready to receive the work of this section. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work if this section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Place topsoil in accordance with Section 31 2200.

B. Loosen sub-grade to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous materials.

C. Spread planting soil mixture to depth required to meet thickness, grades, and elevations shown, after light rolling and natural settlement. Do not spread if planting soil or sub-grade is frozen.
   1. Place approximately 1/2 the thickness of planting soil mixture required. Work into top of loosened sub-grade to create transition layer and then place remainder of planting soil mixture.
   2. Allow for sod thickness in areas to be sodded.

D. Preparation of unchanged grades: where lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare soil as follows:
1. Till surface soil to a depth of at least 6 inches. Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches of soil. Trim high areas and fill in depressions. Till soil to a homogenous mixture of fine texture.
2. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

E. Grade lawn and grass areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1-1/2 inches in any dimension, and other objects that may interfere with planting or maintenance operations.
F. Moistened prepared lawn areas before planting when soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
G. Restore prepared areas if eroded or otherwise disturbed after fine grading and before planting.
H. Topsoil depth shall be a minimum of 4 inches.

3. FERTILIZING
A. Apply fertilizer in accordance with manufacturer's instructions.
B. Apply after smooth raking of topsoil and prior to installation of sod.
C. Apply fertilizer no more than 48 hours before laying sod.
D. Mix thoroughly into upper 2 inches (50 mm) of topsoil.
E. Lightly water to aid the dissipation of fertilizer.

3. LAYING SOD
A. Moisten prepared surface immediately prior to laying sod.
B. Lay sod within 24 hours after harvesting to prevent deterioration. Do not lay sod if dormant or if ground is frozen.
C. Lay sod smooth and tight with no open joints visible, and no overlapping; stagger end joints 12 inches (300 mm) minimum. Do not stretch or overlap sod pieces.
D. Where new sod adjoins existing grass areas, align top surfaces.
E. Where sod is placed adjacent to hard surfaces, such as curbs, pavements, etc., place top elevation of sod 1/2 inch (13 mm) below top of hard surface.
F. Lay sod across angle of slopes exceeding 1:3.
G. On slopes 6 inches per foot (500 mm per m) and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet (600 mm) on center. Drive pegs flush with soil portion of sod.
H. Water sodded areas immediately after installation. Saturate sod to 4 inches (100 mm) of soil. During first week, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below the sod.
I. After sod and soil have dried, roll sodded areas to ensure good bond between sod and soil and to remove minor depressions and irregularities.

3. CLEAN-UP AND PROTECTION
A. During landscaping, keep pavement 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.

3. DISPOSAL OF SURPLUS AND WASTE MATERIALS
A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the owner's property.
3.07 MAINTENANCE

A. Provide maintenance at no extra cost to Owner; Owner will pay for water.

B. Maintain sodded areas immediately after placement until grass is well established and exhibits a vigorous growing condition, but not less than 30 days after date of substantial completion and second full mowing has been performed.

C. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches (65 mm). Do not cut more than 1/3 of grass blade at any one mowing. Do not delay mowing until grass blades bend over and become matted. Do not mow grass when wet.

D. Apply fertilizer to lawn after first mowing and when grass is dry. Use fertilizer that will provide actual nitrogen of at least 1 lb. per 1000 sq. ft. of lawn area.

E. Neatly trim edges and hand clip where necessary.

F. Immediately remove clippings after mowing and trimming.

G. Water to prevent grass and soil from drying out to a uniform depth of 4 inches. Water lawn at the minimum rate of 1 inch per week.

H. Roll surface to remove irregularities.

I. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.

J. Immediately replace sod to areas that show deterioration or bare spots.

K. Protect sodded areas with warning signs during maintenance period.

END OF SECTION
SECTION 32 9300
PLANTS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Preparation of subsoil.
B. Topsoil bedding.
C. New trees, plants, and ground cover.
D. Fertilizer.
E. Maintenance.
F. Tree and Shrub Pruning.

1.02 DEFINITIONS
A. Weeds: Any plant life not specified or scheduled.
B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.03 REFERENCE STANDARDS

1.04 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 with at least 3 years experience and a record of successful landscape establishment.
B. Provide quality, size, genus, species, and variety of trees, shrubs, and plants indicated complying with the applicable requirements of ANSI/AHIA Z60.1.
C. Measure trees and shrubs according to ANSI/AHIA Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4 inch caliper size and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
D. Tree Pruning: Comply with ANSI A300 Part 1.

1.05 DELIVERY, STORAGE, AND HANDLING
A. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by landscape architect. 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 or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.
B. Handle balled and burlapped stock by the root ball.
C. Deliver trees, shrubs, ground covers, and plants 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 and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.
D. Protect and maintain plant life until planted.
E. Deliver plant life materials immediately prior to placement. Keep plants moist.

1.06 FIELD CONDITIONS
A. Do not install plant life when ambient temperatures may drop below 35 degrees F (2 degrees C) or rise above 90 degrees F (32 degrees C).
B. Do not install plant life when wind velocity exceeds 30 mph (48 k/hr).
C. Utilities: Determine location of above grade and underground utilities and perform work in a manner which will avoid damage. Hand excavate as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.
D. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify landscape architect before planting.

1.07 COORDINATION AND SCHEDULING
A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.

1.08 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. Special Warranty: warrant trees, shrubs, and plants for a period of one year after date of substantial completion against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by owner, abnormal weather conditions unusual for warranty period, or incidents that are beyond contractor's control.
C. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty commencing on date of replacement.
   1. Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season.
   2. Replace planting materials that are more than 25% dead or in an unhealthy condition at end of warranty period.
   3. A limit of one replacement of each plant material will be required, except for losses or replacements due to failure to comply with requirements.

PART 2 PRODUCTS

2.01 TREE AND SHRUB MATERIAL
A. Plants: Species and size identified in plant schedule, grown in climatic conditions similar to those in locality of the work.
B. General: Furnish nursery-grown trees and shrubs conforming to ANSI/AHIA 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, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
C. Grade: Provide trees and shrubs of sizes and grades conforming to ANSI/AHIA Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to landscape architect with proportionate increase in size of roots and ball.
D. Label at least 1 tree and 1 shrub of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

2.02 SHADE AND FLOWERING TREES
A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI/AHIA Z60.1 for type of trees required.
B. Small Trees: Small upright or spreading type, branched or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI/AHIA Z60.1.

C. Provide balled and burlapped trees when specified on approved plans.

2.03 SHRUBS AND PERENNIALS

A. Form and Size: Shrubs with not less than the minimum number of canes required by and measured according to ANSI/AHIA Z60.1 for type, shape, and height of shrub.

B. Provide balled and burlapped or container shrubs and perennials.

2.04 SOIL MATERIALS

A. Provide approved imported topsoil required to bring surface to specified elevation relative to walk or curb.

B. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; see Section 32 9113: Soil Preparation for required chemical and physical characteristics.

2.05 SOIL AMENDMENT MATERIALS

A. Fertilizer for Trees and Shrubs: Containing fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, to the following proportions:
   1. Nitrogen: >20% (of which 50% will be organic).
   2. Phosphoric Acid: 10%.
   3. Soluble Potash: 5%.

2.06 ACCESSORIES

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. Verify that prepared subsoil and planters are ready to receive work.

C. Saturate soil with water to test drainage.

3.02 PREPARATION OF SUBSOIL

A. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove stones larger than 1 inch in any dimension, foreign materials, sticks, rubbish, weeds and undesirable plants and their roots. Remove contaminated subsoil.

C. Scarify subsoil to a depth of 6 inches (150 mm) where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

3.03 PLACING TOPSOIL

A. Topsoil depth shall be a minimum of 12 inches.

B. Spread topsoil to a minimum depth of 6 inches (150 mm) over area to be planted. Work into top of loosened sub grade to create a transition layer and then place remainder of planting soil mixture.

C. Till soil in beds to a minimum depth of 8 inches and mix with specified soil amendments and fertilizers.

D. Place topsoil during dry weather and on dry unfrozen subgrade.

E. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
F. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.

3.04 FERTILIZING

A. Apply fertilizer in accordance with manufacturer’s instructions.
B. Apply after initial raking of topsoil and till in to beds.
C. Mix thoroughly into upper 8 inches (203 mm) of topsoil.
D. Lightly water to aid the dissipation of fertilizer.

3.05 EXCAVATION FOR TREES AND SHRUBS

A. Pits and Trenches: Excavate with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.
   1. Balled and Burlapped Trees and Shrubs: Excavate approximately 3 times as wide as ball diameter and equal to ball depth.
   2. Container-Grown Trees and Shrubs: Excavate approximately 3 times as wide as container diameter and equal to root mass depth.
B. Dispose of subsoil removed from landscape excavations. Do not mix with planting soil or use as backfill.
C. Obstructions: Notify landscape architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
D. Drainage: Notify landscape architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.
E. Fill excavation with water and allow to percolate out before placing setting layer and positioning trees and shrubs.

3.06 PLANTING

A. Layout individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, and secure landscape architects acceptance before the start of planting work. Make minor adjustments as needed.
B. Set balled and burlapped stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
   1. Place stock on undisturbed or compacted topsoil.
   2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. 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.
   4. Backfill to consist of one (1) part topsoil and one (1) part native soil clean and free from toxic mineral and chemicals, noxious weeds, rocks larger than 1-1/2 inch in any dimension, and other objectionable materials.
   5. When pit is approximately 1/2 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.
C. Set container-grown stock plumb in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
   1. Carefully remove containers so as not to damage root balls.
   2. Place stock on undisturbed or compacted topsoil.
   3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets.
   4. Backfill to consist of one (1) part topsoil and one (1) part native soil clean and free from toxic mineral and chemicals, noxious weeds, rocks larger than 1-1/2 inch in any dimension, and other objectionable materials.
5. When pit is approximately 1/2 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.

D. Dish and tamp top of backfill to form a 3 inch high mound around the rim of the pit. Do not cover top of root ball with backfill.

3.07 PLANT SUPPORT
A. Brace plants vertically with plant protector wrapped guy wires and stakes to the following:
   1. Tree Caliper: 2 to 4 inches (50 to 100 mm); Tree Support Method: 3 guy wires

3.08 TREE PRUNING
A. Prune trees as recommended in ANSI A300 Part 1.
B. Unless otherwise directed by landscape architect, do not cut tree leaders, remove only dead, broken, and split branches.
C. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning.

3.09 FIELD QUALITY CONTROL
A. Plants will be rejected if a ball of earth surrounding roots has been disturbed or damaged prior to or during planting.

3.10 CLEAN-UP AND PROTECTION
A. During landscaping, keep pavement clean and work area in 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.

3.11 DISPOSAL OF SURPLUS AND WASTE MATERIALS
A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the owner's property.

3.12 MAINTENANCE
A. Provide maintenance at no extra cost to Owner; Owner will pay for water.
B. Maintain plant life for 60 days after date of substantial completion.
C. Irrigate sufficiently to saturate root system and prevent soil from drying out.
D. Remove dead or broken branches and treat pruned areas or other wounds.
E. Neatly trim plants where necessary.
F. Immediately remove clippings after trimming.
G. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions.
H. Control insect damage and disease. Apply pesticides in accordance with manufacturers instructions.
I. Remedy damage from use of herbicides and pesticides.
J. Maintain wrappings, guys, and stakes. Repair or replace accessories when required.

END OF SECTION
SECTION 32 9419
LANDSCAPE SURFACING

PART 1  GENERAL

1.01  SECTION INCLUDES
A. Mulch.
B. Weed barrier
C. Maintenance.

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

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 with at least 3 years experience and a record of successful landscape establishment.

1.04  FIELD CONDITIONS
A. Do not install mulch when wind velocity exceeds 30 mph (48 k/hr).

1.05  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.

PART 2  PRODUCTS

2.01  MULCH MATERIALS
A. Organic Mulch: free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Soil Pep: placed at perennial and surface-rooting ground cover locations.
   2. Bark: Red Long strand, shredded bark at tree, shrub, and groundcover locations not specified above to receive soil pep.
B. Cobble: Rounded, 2 inch minus in size. Color noted on approved drawings.

2.02  ACCESSORIES
A. Weed Control Barrier: 5 oz. woven, needle-punched polypropylene fabric. DeWitt Pro 5 Weed Barrier or landscape architect's approved equivalent.
B. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's instructions.

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. Verify that prepared subsoil and planters are ready to receive work.

3.02  MULCHING
A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.
B. Weed control barriers: Install weed control barriers according to manufacturer's recommendations and before mulching. Completely cover area to be mulched, lapping edges a minimum of 6 inches.
   1. Do not place weed control barrier in shrub and perennial locations.
C. Place soil pep mulch in all shrub and perennial locations.

D. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.
   1. Thickness: 3 inches at shrub and perennial locations.

E. Pea Gravel: Place 3 inch depth rock mulch in areas as shown on plans with weed control barrier beneath.

F. Cobble: Place 3 inch depth cobble in areas as shown on plans with weed control barrier beneath.

3.03 ACCESSORIES

A. Apply antidesiccant using power spray to provide an adequate film or trunks, branches, stems, twigs, and foliage. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

3.04 CLEAN-UP AND PROTECTION

A. During landscaping, keep pavement clean and work area in 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.

3.05 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the owner's property.

3.06 MAINTENANCE

A. Replace mulch when deteriorated.

END OF SECTION