

**PROJECT MANUAL
TOWN OF ELLINGTON
CONNECTICUT**

**Expansion & Renovate as New
CRYSTAL LAKE ELEMENTARY SCHOOL
Phase 1 of 3**

**284 Sandy Beach Road
Ellington, Connecticut 06029**

Connecticut D.O.E. Project No. 048-0058 EA/RR/PS

VOLUME 3 OF 3

**DD Estimate Submission: April 23, 2013
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EXPANSION & RENOVATE AS NEW – PHASE 1

**CRYSTAL LAKE ELEMENTARY SCHOOL
284 SANDY BEACH ROAD
ELLINGTON, CT 06029
STATE PROJECT NO. 048-0058 EA/RR/PS**

S/P+A PROJECT NO. 12.140

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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.
3. Iron ball valves.
4. Iron, single-flange butterfly valves.
5. Bronze swing check valves.
6. Iron swing check valves.
7. Iron, center-guided check valves.
8. Bronze gate valves.
9. Iron Gate valves
10. Bronze globe valves. Iron globe valves.
11. Iron Globe
12. Chainwheels.

B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "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 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.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle, gate, and globe valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 5. Set butterfly valves closed or slightly open.
 - 6. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to HVAC valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 and larger

2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. 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 150, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
 - a. Crane Co.; Crane Valve Group; Stockham Division.
 - b. Kitz Corporation.
2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron.

2.3 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. Milwaukee Valve Company

2. Description:

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

2.4 IRON BALL VALVES

A. Class 150, Iron Ball Valves:

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

- a. American Valve, Inc.
- b. Conbraco Industries, Inc.; Apollo Valves.
- c. Kitz Corporation.
- d. Sure Flow Equipment Inc.
- e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: 285 psig.
- c. Body Design: Split body.
- d. Body Material: ASTM A 126, gray iron.
- e. Ends: Flanged.
- f. Seats: TFE.
- g. Stem: Stainless steel. Blowout –proof.
- h. Ball: Stainless steel.
- i. Port: Full.
- j. Flanged ends.

2.5 IRON, SINGLE-FLANGE BUTTERFLY VALVES

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

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

- a. American Valve, Inc.
- b. Conbraco Industries, Inc.; Apollo Valves.
- c. Hammond Valve.
- d. Kitz Corporation.
- e. Milwaukee Valve Company.
- f. 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.

2.6 BRONZE SWING CHECK VALVES

A. 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. Milwaukee Valve Company.
- d. Hammond Valve.
- e. Kitz Corporation.

2. Description:

- a. Standard: MSS SP-80, Type 3.
- b. CWP Rating: 300 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

2.7 IRON SWING CHECK VALVES

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

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

- a. Crane Co.; Crane Valve Group; Crane Valves.
- b. Hammond Valve.

- c. Milwaukee Valve Company.
2. Description:
- a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, 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.
 - h. Style: Compact wafer.
 - i. Seat: EPDM.

2.8 IRON, CENTER-GUIDED CHECK VALVES

A. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. APCO Willamette Valve and Primer Corporation.
 - b. Crispin Valve.
 - c. Val-Matic Valve & Manufacturing Corp.
- 2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - d. Style: Compact wafer.
 - e. Seat: Bronze.

2.9 BRONZE GATE VALVES

A. Class 150, RS Bronze Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. Hammond Valve.
 - e. Kitz Corporation.
- 2. Description:
 - a. Standard: MSS SP-80, Type 2.

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

2.9 IRON GATE VALVES

B. Class 250, OS&Y, Iron Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Powell Valves.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

2.10 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. Kitz Corporation.
 - e. NIBCO INC.
- 2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.

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

2.11 IRON GLOBE VALVES

A. 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.

2.12 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Babbitt Steam Specialty Co.
 - b. Roto Hammer Industries.
 - c. Trumbull Industries.
- B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 - a. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 - b. Attachment: For connection to ball valve stems.
 - c. Sprocket Rim with Chain Guides: Ductile iron of type and size required for valve. Include zinc coating.
 - d. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for ball, butterfly, gate and globe valves, NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- F. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Throttling Service except Steam: Globe valves.
 - 4. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.

- b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, resilient-seat check valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - 2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
 - 3. For Steel Piping NPS 5 and Larger: Flanged ends.

3.5 HEATING-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 150, bronze disc.
 - 3. Ball Valves: Two piece, full port, bronze with bronze trim.
 - 4. Bronze Swing Check Valves: Class 150, bronze disc.
 - 5. Bronze Gate Valves: Class 150, RS.
 - 6. Bronze Globe Valves: Class 150, bronze disc.
- B. Pipe NPS 2-1/2 and Larger:
 - 1. Iron Valves, NPS 2-1/2 to NPS 4: flanged ends.
 - 2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
 - 3. Iron Swing Check Valves: Class 250, metal seats.

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.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
4. Division 23 Section Metal Ducts for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 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.
 3. Pipe stands.
 4. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Detail fabrication and assembly of trapeze hangers.
 2. Design Calculations: Calculate requirements for designing trapeze hangers.
- D. Welding certificates.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.

4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Strut Inc.
 - b. Unistrut Corporation; Tyco International, Ltd.
 - c. Wesanco, Inc.
 - d. GS Metals Corp.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturred lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: 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.
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 inturred 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: 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.
 2. Clement Support Services.
 3. ERICO International Corporation.
 4. National Pipe Hanger Corporation.
 5. PHS Industries, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

2.6 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

- C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- E. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

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1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. 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.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. 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 (DN 65) 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.
- L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. 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.

N. 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.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 PIPE HANGERS AND SUPPORT SPACING

- A. Support horizontal steel and copper as follows:
1. 1/2" to 1 1/4" Pipe Size : 6'-0" maximum hanger spacing.
 2. 1 1/2" to 2" Pipe Size : 10'-0" maximum hanger spacing.
 3. 2 1/2" to 3" Pipe Size : 10'-0" maximum hanger spacing.
 4. 4" to " Pipe Size : 10'-0" maximum hanger spacing.

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 bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

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/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.

3.5 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. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in 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.

3.7 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.

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- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. 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.

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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.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS 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. This Section includes the following:
 - 1. Isolation Pads.
 - 2. Isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Restrained spring isolators.
 - 5. Housed spring mounts.
 - 6. Elastomeric hangers.
 - 7. Spring hangers with vertical-limit stops.
 - 8. Pipe riser resilient supports.
 - 9. Resilient pipe guides.
 - 10. Restrained vibration isolation roof-curbs.
 - 11. Seismic snubbers.
 - 12. Restraining braces and cables.
 - 13. Steel vibration isolation equipment bases.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide wind and seismic restraints in accordance with the requirements of the Connecticut State Building Code.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:

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1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
- B. 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and wind forces required to select vibration isolators, seismic and wind 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 22 Sections for equipment mounted outdoors.
 2. 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.
 3. 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.
 4. Seismic and Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind 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. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
- C. 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.
- D. Welding certificates.

1.6 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.

- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control test reports.

1.7 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, "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.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mason Industries.
 - 2. Isolation Technology, Inc.
 - 3. Kinetics Noise Control.
 - 4. Vibration Eliminator Co., Inc.
 - 5. Vibration Isolation.
- A. Pads. Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene.
- B. Restrained Mounts: All-directional mountings with seismic restraint.

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

1. Materials: Cast-ductile-iron or welded steel housing containing two (2) separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to ¼ inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
 5. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
 6. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
- D. Housed Spring Mounts Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
 2. Base: Factory drilled for bolting to structure.
 3. Snubbers: Vertically adjustable to allow a maximum of ¼-inch travel up or down before contacting a resilient collar.
- E. Elastomeric Hangers: Double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
- F. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
 4. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
 5. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

- G. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of two (2) steel tubes separated by a minimum of ½-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
- H. Resilient Pipe Guides: Telescopic arrangement of two (2) steel tubes or post and sleeve arrangement separated by a minimum of ½-inch-thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURBS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Mason Industries.
 - 2. Isolation Technology, Inc.
 - 3. Kinetics Noise Control.
 - 4. Thybar Corporation.
 - 5. Vibration Eliminator Co., Inc.
 - 6. Vibration Isolation.
- B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
- C. Lower Support Assembly: Formed sheet-metal “Z” section containing adjustable and removable steel springs that support upper floating frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. 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.
- D. The curb shall be built to seismically contain the roof top unit. The unit must be solidly fastened to the top floating rail and the lower section anchored to the roof structure.
- E. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on ¼-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.

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

- b. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
 - d. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
 - e. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - a. Resilient Material: Oil- and water-resistant natural rubber.
- F. Snubber Bushings: All-directional, elastomeric snubber bushings at least ¼ inch thick.
- G. 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 counterflashed over roof materials.
- H. Acoustic Barrier Package: The package shall consist of high transmission loss 2 inch thick panel assembly. The panel shall be constructed of two (2) sheets of 16 gauge galvanized steel, filled with insulation, 2 inch thick, 1.25 lbs/cu ft minimum density.

2.3 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Mason Industries.
 2. Amber/Booth Company, Inc.
 3. California Dynamics Corporation.
 4. Isolation Technology, Inc.
 5. Kinetics Noise Control.
 6. Vibration Eliminator Co., Inc.
 7. Vibration Isolation.
 8. Vibration Mountings & Controls, Inc.
- B. Steel Base: 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. 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. Anchor-bolt templates from supported equipment manufacturer.

2.4 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. Mason Industries.
 2. Amber/Booth Company, Inc.
 3. California Dynamics Corporation.
 4. Cooper B-Line, Inc.; a division of Cooper Industries.
 5. Hilti, Inc.
 6. Kinetics Noise Control.
 7. Loos & Co.; Cableware Division.
 8. TOLCO Incorporated; a brand of NIBCO INC.
 9. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) 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 ¼ inch air gap, and minimum ¼ inch-thick resilient cushion.
- D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- E. Restraint Cables: ASTM A 603 galvanized 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 (2) clamping bolts for cable engagement.
- F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- H. 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.

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

- I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- J. 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 (8) times diameter.
- K. 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.

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- and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- 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 APPLICATIONS

- A. 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.
- B. 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.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Equipment Restraints:
 - 1. 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.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- C. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- D. Install cables so they do not bend across edges of adjacent equipment or building structure.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- G. 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.
- H. 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.
- I. 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.

3.4 VIBRATION ISOLATION AND SEISMIC RESTRAINT OF DUCTWORK

A. Vibration Isolation of Ductwork

1. All discharge runs for a distance of 50 feet from the connected equipment shall be isolated from the building structure by means of specification 10 hangers or specification 5 floor isolators. Spring deflection shall be a minimum of 0.75 inch.
2. All duct runs having air velocity of 1000 fpm or more shall be isolated from the building structure by specification 11 hangers or 5 floor supports. Spring deflection shall be a minimum of 0.75 inch.

B. Seismic Restraint of Ductwork

1. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.
2. Restrain round ducts with diameters of 28 inches or larger.
3. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
4. Transverse restraints shall occur at 30 foot intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
5. Longitudinal restraints shall occur at 60 foot intervals with at least one (1) restraint per duct run. Transverse restraints for one (1) duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4 feet of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
6. The ductwork 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.
7. 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.
8. 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.
9. Connection to the structure must be made with a non-friction connection.

C. Ductwork Exclusions

1. Rectangular and square and ducts that are less than 6 square feet in cross sectional area.
2. All trapezed ductwork where the distance from the suspension point to the trapeze member is 12 inches or less.
3. Ductwork hung with straps where the top of the duct is 12 inches or less from the suspension point and the strap has two (2) #10 sheet metal screws within 2 inches of the top of the duct.
4. If any suspension location in the run exceeds the above, the entire run must be braced.

3.5 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.

3.6 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. 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 postconnection testing has been approved), and with at least seven (7) days advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to ninety percent (90%) of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 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.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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 (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: Black

C. Background Color: Yellow.

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

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

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

- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- D. 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.
- E. Fasteners: Stainless-steel rivets or self-tapping screws.
- F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- G. 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 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 chain.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.
- C. Valve Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Included mounting screws.
 1. Frame: Extruded Aluminum.
 2. Glazing: ASTM C1036, Type I, Class I, Glazing Quality B, 2.5-mm, single thickness glass.

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: Reinforced grommet and wire or string.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
Color: Yellow background with black lettering.

- 2.7 ACCESS PANEL AND DOOR MARKERS: 1/16-inch thick, engraved laminated plastic with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Fasteners: Self-tapping, stainless steel screws or contact type, permanent adhesive.

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. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule:
- a. Hot Water:
 - 1) Background Color: Yellow
 - 2) Letter Color: Black
 - b. Gas:
 - 1) Background Color: Yellow
 - 2) Letter Color: Black

3.4 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 - 1. Blue: For cold-air supply ducts.
 - 2. Yellow .:For hot-air supply ducts.
 - 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
 - 4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
- B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Hot Water: 1-1/2 inches round.
 - b. Gas: 1-1/2 inches) round.
 - 2. Valve Tag Color:
 - a. Hot Water: Natural
 - b. Gas: Natural
 - 3. Letter Color:
 - a. Hot Water: Black
 - b. Gas: Black

3.6 VALVE SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 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.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Division 01 Section 019113 “General Commissioning Requirements”.

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - 2. Balancing Hydronic Piping Systems:
 - a. Variable-flow hydronic systems.
 - b. Primary-secondary hydronic systems..

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 ACTION SUBMITTAL

- A. High Performance Building: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 – “ Air Balancing”
- B. TAB Report: Documentation of work performed for ASHRAE 90.1 Section 6.7.2.3- “ System Balancing”

1.5 INFORMATION SUBMITTALS

- A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 15 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. Certified TAB reports.
- E. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.
- B. TAB Conference: Meet with Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. 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.

- D. TAB Report Forms: Use standard TAB contractor's forms approved by Commissioning Authority.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.7 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.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- C. Owner Occupancy for multiple construction phases. Owner will occupy the building at the completion of each construction phase. Coordinate with the construction phasing plan.

1.8 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. A factory-authorized service representative and the BAS Contractor shall be present when balancing and testing major equipment.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

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.

TESTING, ADJUSTING AND BALANCING FOR HVAC

- B. Examine the Contract Documents to become familiar with Project phasing plan and to become familiar with the TAB requirements at the end of each construction phase.
- C. 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.
- D. Examine the approved submittals for HVAC systems and equipment.
- E. 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.
- 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 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 TESTING, ADJUSTING AND BALANCING FOR MULTIPLE PHASES

- A. At the end of each phase:
 - 1. Performed TAB for all systems scheduled to operate as part of each phase.
 - 2. Adjust heating and cooling systems, as required, to accommodate additional equipment at each phase.
 - 3. Generate report at the end of each phase.
- B. At the completion of the project:
 - 1. Perform TAB for the whole system.
 - 2. Retest, readjust and rebalance all system previously tested and balanced at each phase.
 - 3. Generate complete final report.

3.4 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.

3.5 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.6 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. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. 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.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling-unit components.
- K. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.7 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 Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.8 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 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.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 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. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.

- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.13 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

- A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

3.15 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.

3.16 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.

3.17 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 to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.18 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

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

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit /Dedicated Outdoor 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.

F. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch o.c.
- f. Make and model number.

- g. Face area in sq. ft..
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
- a. Air flow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
- a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
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 (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
- a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.

- d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
- 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated air flow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual air flow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary air flow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final air flow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
- 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.

- d. Coil make and size.
 - e. Flowmeter type.
2. Test Data (Indicated and Actual Values):
- a. Air flow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
1. Unit Data:
- a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- L. Instrument Calibration Reports:
1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.19 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 Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
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.

3.20 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.

3.21 FOLLOW-UP SERVICES

- A. Allow for ten (10) scheduled visits during the six month period following substantial completion to adjust system parameters based on Owner's observations.

END OF SECTION 230593

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, concealed exhaust between isolation damper and penetration of building exterior.
 - 7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 8. Outdoor, concealed supply and return.
 - 9. Outdoor, exposed supply and return.
- B. Related Sections:
 - 1. Division 23 Section "HVAC Equipment Insulation."
 - 2. Division 23 Section "HVAC Piping Insulation."
 - 3. Division 23 Section "Metal Ducts" for duct liners.

1.3 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. HPBS Submittals:
 - 1. Product Data for Section 16a-38k-5(d): For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
 - 2. Laboratory Test Reports for Section 16a-38k-5(d): For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. 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.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
1. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 2. Sheet Jacket Materials: 12 inches (300 mm) square.
 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.
- E. Qualification Data: For qualified Installer.
- F. 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.
- G. Field quality-control reports.

1.4 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.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "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.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. 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.
- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. 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 having jurisdiction.
- 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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, provide one of the following::
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
1. Products: Subject to compliance with requirements, provide one of the following :

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
 - b. Eagle Bridges - Marathon Industries; 501.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
 - d. Mon-Eco Industries, Inc.; 55-10.
- 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 - 3. Service Temperature Range: 0 to 180 deg F.
 - 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 5. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Eagle Bridges - Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg F .
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: 60 percent by volume and 66 percent by weight.
 - 5. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
 - c. Vimasco Corporation; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - 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 (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.

1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

2.8 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. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Metal Jacket:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 - 2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - 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: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 2.5-mil- thick polysurlyn.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 - 2. Width: 3 inches.
 - 3. Thickness: 11.5 mils.
 - 4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. 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.

2.11 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. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 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. 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.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel .
 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. C & F Wire.

2.12 CORNER ANGLES

- A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

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 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

- 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to 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 Division 07 Section "Penetration Firestopping"irestopping 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 Division 07 Section "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 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 Division 07 Section "Penetration Firestopping."

3.8 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

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:
 - 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 two location(s) 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.

3.10 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, concealed exhaust between isolation damper and penetration of building exterior.
 - 7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 8. Outdoor, concealed supply and return.
 - 9. Outdoor, exposed supply and return.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Insulated Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round and flat-oval, supply-air duct insulation shall be :
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- B. Concealed, round and flat-oval, return-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.

- C. Concealed, round and flat-oval, outdoor-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- D. Concealed, round and flat-oval, exhaust-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- E. Concealed, rectangular, supply-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- F. Concealed, rectangular, return-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- G. Concealed, rectangular, outdoor-air duct insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket; thickness as required to achieve 2-hour fire rating.
- J. Concealed, exhaust-air plenum insulation shall be:
 - 1. Mineral-Fiber Blanket: Minimum installed R Value of 5.
- K. Exposed, rectangular, supply-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 5.
- L. Exposed, rectangular, return-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 5.
- M. Exposed, rectangular, outdoor-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 5.
- N. Exposed, rectangular, exhaust-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 5.
- O. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated board; thickness as required to achieve 2-hour fire rating.
- P. Concealed and Exposed, supply, return, exhaust and outdoor-air ductwork and plenum located outside the building envelop insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 8.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, rectangular, supply-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 8.

- B. Concealed, rectangular, return-air duct insulation shall be the following:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 8.
- C. Exposed, rectangular, supply-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 8.
- D. Exposed, rectangular, return-air duct insulation shall be:
 - 1. Mineral-Fiber Board: Minimum installed R Value of 8.

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. Ducts and Plenums, Concealed:
 - 1. Aluminum, Smooth with Z-Shaped Locking Seam: 0.032 inch thick
- C. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 - 1. Painted Aluminum, Smooth with Z-Shaped Locking Seam: 0.032 inch thick.

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. Heating hot water piping.
 - 2. Refrigerant suction piping.
- B. Related Sections:
 - 1. Division 23 Section "HVAC Equipment Insulation."
 - 2. Division 23 Section "Duct Insulation."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. HPBS Submittals:
 - 1. Product Data for Section 16a-38k-5(d): For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
 - 2. Laboratory Test Reports for Section 16a-38k-5(d): For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. 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 pipe expansion joints for each type of insulation.
 - 3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 4. Detail removable insulation at piping specialties.
 - 5. Detail application of field-applied jackets.
 - 6. Detail application at linkages of control devices.

- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - 2. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. 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.

1.6 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 Division 23 Section "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.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," and "Outdoor, Aboveground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. 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.
- G. 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.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Ramco Insulation, Inc.; Super-Stik.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Ramco Insulation, Inc.; Thermokote V.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
 1. Products: Subject to compliance with requirements, 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. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 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.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 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:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 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.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Eagle Bridges - Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 3. Service Temperature Range: Minus 50 to plus 220 deg F.
 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 5. Color: White.
- 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:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: 60 percent by volume and 66 percent by weight.
 5. Color: White.

D. LAGGING ADHESIVES

1. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
2. 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).
3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
 - c. Vimasco Corporation; 713 and 714.
4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
5. Service Temperature Range: 0 to plus 180 deg F.
6. Color: White.

2.5 SEALANTS**A. Joint Sealants:**

1. Joint Sealants for, Phenolic,: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

- b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: Aluminum.
 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: Color-code jackets based on system. Color as selected by Architect.
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- C. Metal Jacket:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 - 2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 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.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. 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. Compac Corporation; 130.
 - b. Venture Tape; 1506 CW NS.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.

6. Tensile Strength: 18 lbf/inch in width.

D. 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.

2.9 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. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 1/2 inch wide with wing seal.

B. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. C & F Wire.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 PENETRATIONS

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

- B. Insulation Installation at 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: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets,

- valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

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 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

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

C. 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.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.9 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. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FINISHES

- A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

D. Do not field paint aluminum jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three] locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 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.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. Listed thicknesses shall be based on conductivity values of 0.25-0.29 BTU-IN/HR-FT²-Deg F per ASTM C547.
2. Smaller than NPS 4: Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
3. NPS 4 and Larger: Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe, Type I: 1 1/2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. NPS 1 1/2 and Smaller: Insulation shall be:
 - a. Cellular Glass: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I, 1 inch thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. NPS 1 1/2 and Smaller: Insulation shall be:
 - a. Cellular Glass: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I, 1 inch thick.

3.15 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, Color-Coded by System: 20 mils thick.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 1. None.
- C. Piping, Exposed:
 1. Painted Aluminum, Smooth with Z-Shaped Locking Seam: 0.024 inch thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

1.5 ALLOWANCES

- A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Section 012100 "Allowances."

1.6 UNIT PRICES

- A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Section 012200 "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.7 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meeting.
- C. Attend testing, adjusting, and balancing review and coordination meeting.
- D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.8 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.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 Testing AND BALANCING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

-
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 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 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.
 3. Minimum flushing water velocity.
 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 chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 230800

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only.
- B. All labor, material, equipment, software drivers, 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.

1.2 DEFINITIONS

- A. Definitions of the acronyms used in this specification are as follows:

- 1. DDC Direct Digital Controls
- 2. CC Configurable Controller
- 3. FMCS Facility Management and Control System
- 4. GUI Graphical User Interface
- 5. IDC Interoperable Digital Controller
- 6. INC Interoperable Niagara^{AX} Controller
- 7. LAN Local Area Network
- 8. NAC Network Area Controller
- 9. NICS Niagara Compatibility Statement
- 10. OOT Object Oriented Technology
- 11. PEC Programmable Equipment Controller
- 12. PICS Product Interoperability Compliance Statement
- 13. PMI Power Measurement Interface
- 14. POT Portable Operator's Terminal
- 15. TCS Temperature Control System
- 16. WAN Wide Area Network
- 17. WBI Web Browser Interface

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Sensors and Transmitters:

- 1. Flow meters
- 2. Press and temp sensor wells and sockets
- 3. Temp sensor wells and sockets

- B. Control Valves:

- 1. Control valves

C. Control Dampers:

1. Automated dampers

1.4 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. General:

1. Coordination Meeting: The Installer furnishing the DDC network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network. The Owner or his designated representative shall be present at this meeting. Each Installer shall provide the Owner and all other Installers with details of the proposed interface including:
 - a. Rooftop Equipment Manufacturer
 - b. ERV Manufacturer
2. Direct Digital Controllers conforming to either the LonMark interoperability specification, or the BACnet, ANSI/ASHRAE Standard 135-2004 specification may be used.
 - a. BACnet: PICS, hardware, and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories.
 - b. LonTalk: All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.
3. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.

B. Central HVAC Equipment:

1. Packaged AHU or Evaporative Cooler Controls: Unit shall be furnished configured to accept control inputs from an external building automation system controller as specified. Factory mounted safeties and other controls shall not interfere with this controller.

C. Decentralized HVAC Equipment:

1. Unit Ventilators, Unit Heaters, Fan Coils, Etc.: Unit ventilators, unit heaters, fan coils, cabinet heaters, convective or fin tube heaters, zone reheat, and similar terminal units. These units shall be furnished without

controls. The controls contractor shall install all controls necessary to complete the sequence of operations given for each unit type.

D. Low-Voltage Controllers:

1. Variable Frequency Drives: The variable frequency drive (VFD) vendor shall furnish VFDs with an interface to the control and monitoring points specified. These specified points shall be the minimum acceptable interface to the VFD. The connection to these points shall be by one (1) of the following methods:
 - a. Hardwired connection such as relay, 0-10VDC, or 4-20mA.
 - b. LonTalk protocol using FTT-10A transceivers.
 - c. BACnet/IP network connection.
 - d. BACnet MS/TP network connection.

E. Communications with Third Party Equipment:

1. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a BACnet interface for integration into the Direct Digital Control System described in this section.

F. Agency and Code Approvals

1. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied. Verification that the applicable 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:
 - a. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - b. ANSI/ASHRAE Standard 135-2004, BACnet.
 - c. Uniform Building Code (UBC), including local amendments.
 - d. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
 - e. National Electrical Code (NEC).
 - f. FCC Part 15, Subpart J, Class A
 - g. EMC Directive 89/336/EEC (European CE Mark)
2. City, county, state, and federal regulations and codes in effect as of contract date.

- a. Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

1.5 SYSTEM DESCRIPTION

- A. The entire Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk and/or BACnet communication protocols to a Network Area Controller (NAC). Any other communication protocols are not acceptable.

1.6 SCOPE OF WORK

- A. The Facility Management and Control System (FMCS) Contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control as herein specified. The system shall include all required computer software and hardware, controllers, sensors, transmission equipment, system workstations, local panels, conduit, wire, installation, engineering, database and setup, supervision, commissioning, acceptance test, training, warranty service and, at the Owner's option, extended warranty service.
- B. The system shall use LonTalk[®] as its native protocol and shall as a minimum include the capability of simultaneous communicating to native BACnet and MODBUS components. System components shall be certified by LONMARK[®] and display the LONMARK[®] logo where applicable. System components that do not have a published LONMARK[®] profile shall be compatible with the LONMARK[®] standards. For each LonWorks device that does not have LonMark certification, the device supplier must provide DRF and XIF files for the device.
- C. The FMCS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. Systems requiring additional software (to enable a standard Web browser) to be resident on a client machine, or manufacture-specific browsers shall not be acceptable.
- D. The FMCS shall communicate to third party systems such as chillers, boilers, air handling systems, energy metering systems, other energy management systems, access control systems, fire-life safety systems and other building management related devices with open, interoperable communication capabilities.
- E. Systems that are not native LonTalk must demonstrate integration of LonTalk components. Use of a gateway for integration of LonTalk or BACnet devices is not acceptable. All suppliers must be able to demonstrate three (3) proof source

sites where integration of LonTalk interoperability is functioning. Additionally, BACnet components must comply to ASHRAE/ANSI 135-2004 and support the proper level (PICS) to ensure compatibility.

- F. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project.

1.7 RELATED WORK SPECIFIED ELSEWHERE

- A. Drawings and general provisions of the Contract, including General and supplementary Conditions and Division-1 specification sections, apply to work of this section.
- B. Products furnished but not installed under this section:
 - 1. Valves, flow switches, flow sensors, thermowells and pressure taps to be installed under Division 15.
 - 2. Automatic dampers to be installed under Division 15.
- C. Coordination with electrical:
 - 1. Installation of all line voltage power wiring by Division 16.
 - 2. Each motor starter provided under Division 16, shall be furnished with individual control power transformer to supply 120-volt control power and auxiliary contacts (one N.O. and one N.C.) for use by this section.
- D. Wiring of any electrical sub-metering devices furnished by FMCS Contractor.

1.8 QUALITY ASSURANCE

- A. The system shall be furnished, engineered, and installed by the manufacturers' locally authorized representative. The controls contractor shall have factory-trained technicians to provide instruction, routine maintenance, and emergency service within twenty-four (24) hours upon receipt of request.
- B. At the time of bid, all FMCS Configurable Controllers and Programmable Equipment Controllers shall be listed as follows:
 - 1. American Society for testing and materials, ASTM
 - 2. Institute of Electrical and Electronic Engineers, IEEE
 - 3. National Electrical Manufacturers Association, NEMA
 - 4. Underwriters Laboratory, UL 916
 - 5. FCC Regulation, Part 15, Section 156
 - 6. National Fire Protection Association, NFPA
 - 7. Local building codes

- C. The Manufacturer of the FMCS digital controllers shall provide documentation supporting compliance with ISO-9000:2000 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the FMCS digital controller manufacturer shall contain the ISO-9000:2000 Certification Mark from the applicable registrar.

1.9 SUBMITTALS

- A. Submit six (6) complete sets of documentation in the following phased delivery schedule:
 - 1. Valve and damper schedules
 - 2. Equipment data cut sheets
 - 3. System schematics, including:
 - a. Sequence of operations
 - b. Point names
 - c. Point addresses
 - d. Point to point wiring
 - e. Interface wiring diagrams
 - f. Panel layouts
 - g. System riser diagrams
 - 4. Visio[®] or AutoCAD compatible as-built drawings
- B. Upon project completion, submit operation and maintenance manuals, consisting of the following:
 - 1. Index sheet, listing contents in alphabetical order.
 - 2. Manufacturer's equipment parts list of all functional components of the system, disk of system schematics, including wiring diagrams.
 - 3. Description of sequence of operations.
 - 4. As-Built interconnection wiring diagrams.
 - 5. User's documentation containing product, system architectural and programming information.
 - 6. Trunk cable schematic showing remote electronic panel locations, and all trunk data.
 - 7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.).
 - 8. Copy of the warranty.
 - 9. Recommended spare parts list.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Basis of Design: Siemens Talon
- B. Additional Manufacturers:
 - 1. Distech Controls – EC-Net AX
 - 2. Teletrol – ebuilding
 - 3. Alerton
- C. Controls shall be microprocessor based Interoperable Niagara^{AX} Controllers in accordance with the JSR-60 Baja Specification. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.
 - 1. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line. The use of field level controllers from multiple manufacturers is acceptable provided no proprietary configuration or programming software is needed. All field level controllers must be fully configurable through the Niagara^{AX} automation level controller and/or Niagara^{AX} software.
 - 2. Other products specified herein (such as sensors, valves, dampers and actuators) need not be manufactured by the above manufacturers.

2.2 QUALITY ASSURANCE

- A. Installer and Manufacturer Qualifications
 - 1. Installer shall have an established working relationship with Control System Manufacturer.
 - 2. Installer shall have successfully completed Manufacturer's control system training and certification process. Upon request, Installer shall present record of completed training and certifications including course outlines.
 - 3. Installing company shall have ten (10) years experience installing DDC Control Systems.

2.3 CODES AND STANDARDS

- A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect thirty (30) days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)
2. International Building Code (IBC)
 - a. Section 719 Ducts and Air Transfer Openings
 - b. Section 907 Fire Alarm and Detection Systems
 - c. Section 909 Smoke Control Systems
3. International Mechanical Code (IMC)

2.4 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of twelve (12) months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within twenty-four (24) hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

2.5 OWNERSHIP OF PROPRIETARY MATERIAL

- ### A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
1. Graphics

2. Record drawings
3. Database
4. Application programming code
5. Documentation
6. Provide to the Owner the highest level administrative password for the system. This password is to be filed away by the Owner and not used during the warranty period. This is to protect the Owner's interest in the system they purchased.

2.6 INTEROPERABLE DIGITAL CONTROLLER (IDC)

- A. Controls shall be microprocessor based Interoperable LonMark™ or LonWorks Controllers (IDC). 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 to the Owner. Publicly available specifications for the Applications Programming Interface (API) must be provided to the Owner for each LonWorks/LonMark controller defining the programming or setup of each device. The Division 15 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 Network Area Controller (NAC), will provide all scheduling, alarming, trending, and network management for the LonMark/LonWorks based devices.
- D. The IDCs shall communicate with the NAC 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.
- E. 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 ten percent (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.
- F. The Division 15 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

- G. It is the responsibility of the Division 15 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 located in the POINTS LIST section.
- H. The supplier of any programmable IDC shall provide one (1) copy of the manufacturer's programming tool, with documentation, to the Owner.

2.7 LONMARK DEVICES

The Facility Management Control System (FMCS) shall be comprised of a network of interoperable, stand-alone digital controllers. The FMCS shall incorporate LonWorks™ technology using Free Topology Transceivers (FTT-10), and specific conformance to the LONMARK™ Interoperability Association's v3.0 Physical Layer guidelines in all unitary, terminal and other device controllers. The system shall include:

- A. Network Area Controllers (NAC's) for distributed system applications, databases and networking functions, shall conform to the LONMARK Application Layer V3.3 and higher Interoperability Guidelines.
- B. Programmable Equipment Controllers (PEC's) for control of primary mechanical systems and distributed system applications. Controllers shall be fully programmable to create custom control solutions. They shall conform to the LONMARK Application Layer V3.0 and higher Interoperability Guidelines.
- C. Configurable Controllers (CC's) for control of terminal equipment, air handling units, roof top units, and miscellaneous input/output points. They shall conform to the LONMARK Application Layer V3.3 Interoperability Guidelines.
- D. Graphical User Interface (GUI), which includes the hardware and software necessary for a user to interface with the control system and devices.
- E. The physical network shall use polarity insensitive twisted pair wiring and support star, home run, multi-drop, loop, or a mixture of these wiring topologies. The network shall communicate at a minimum 78Kbps.
- F. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass control data shall not be acceptable.
- G. To prevent any node from flooding the network with message traffic and ensure the receipt of critical data in a timely manor, the maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed five (5) seconds for network connected user interfaces. All LonWorks components and controllers shall support maximum send time and minimum send time.

- H. Communication and integration of 3rd party LONMARK® products shall be accomplished without gateways or interface devices. The 3rd party product supplier shall provide DRF and XIF files for each device.
- I. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed sixty (60) seconds for remote or dial-up connected user interfaces.

2.8 INTEROPERABLE BACNET CONTROLLER (IBC)

- A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the ANSI/ASHRAE Standard 135-2004. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-2004, Owner.
- B. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps or via the RS485 connection at a baud rate of not less than 38 kbps.
- C. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a ten percent (10%) spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- D. The Division 15 contractor supplying the IBC's shall provide documentation for each device, with the following information at a minimum:
 - 1. BACnet Device; MAC address, name, type and instance number
 - 2. BACnet Objects; name, type and instance number
- E. It is the responsibility of the Division 15 contractor to ensure that the proper BACnet objects are provided in each IBC, as required by the Point Charts located in the POINTS LIST section.

2.9 INTEROPERABLE NIAGARA^{AX} CONTROLLERS (INC)

- A. Controls shall be microprocessor based Interoperable Niagara Controllers (INC) in accordance with the JSR-60 Baja Specification. INCs shall be provided for applications as shown on the drawings. The application control program shall be resident within the same enclosure as the discrete input/output circuitry, which translates the sensor and actuator signals. The INC may communicate serially using standard protocols with control devices of the equipment that it is

controlling. The INCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.

- B. All INCs shall be fully application programmable. Controllers offering application selection only (non-programmable), require a ten percent (10%) spare point capacity to be provided for all applications. All control sequences within or programmed into the INC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- C. The Division 15 contractor supplying the INCs shall provide documentation for each device, with the following information at a minimum:
 - 1. IP and MAC address, name, type and HostID
 - 2. Niagara Objects; name, type and instance number
- D. It is the responsibility of the Division 15 contractor to ensure that the proper Niagara objects are provided in each INC, as required by the Point Charts located in the POINTS LIST section.

2.10 NETWORK AREA CONTROLLER (NAC)

- A. The controls contractor shall supply one (1) or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices provided under Divisions 15 and 16. It is the responsibility of the controls contractor to coordinate with the Division 15 and 16 contractors to determine the quantity and type of devices.
- B. The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. 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 controller data through Niagara^{AX} drivers installed in the NAC.
 - 7. Network Management functions for all controllers
- C. The Network Area Controller must provide the following hardware features as a minimum:
 - 1. One (1) Ethernet Port – 10/100 Mbps
 - 2. One (1) RS-232 port

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3. One (1) LonWorks Interface Port – 78KB FTT-10A
 4. One (1) RS-485 ports
 5. Battery Backup
 6. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
 7. The NAC must be capable of operation over a temperature range of 32 to 122°F
 8. The NAC must be capable of withstanding storage temperatures of between 0 and 158°F
 9. The NAC must be capable of operation over a humidity range of five to ninety-five percent (5-95%) RH, non-condensing
- D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- E. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of thirty-two (32) simultaneous users.
- F. Event Alarm Notification and actions
1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or 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
 4. Provide for the creation of a minimum of eight (8) of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
 5. Provide timed (schedule) routing of alarms by class, object, group, or node.
 6. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- 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)
 - 5. Printed message, routed directly to a dedicated alarm printer
- I. The following shall be recorded by the NAC 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 NAC 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.

2.11 DATA COLLECTION AND STORAGE

- A. The NAC 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 NAC 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 interval.
 - 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 NAC 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. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.

- G. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - 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 it's user-defined capacity of data stores
 - 4. Provide ability to clear logs once archived

2.12 AUDIT LOG

- A. Provide and maintain an Audit Log that tracks all activities performed on the NAC. 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 NAC), to another NAC 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.

2.13 DATABASE BACKUP AND STORAGE

- A. The NAC 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 NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
- C. The NAC 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.

2.14 PROGRAMMABLE EQUIPMENT CONTROLLERS (PEC)

- A. Programmable Equipment Controllers (PEC's) shall be stand-alone, multi-tasking, real-time digital control processors.
- B. The PEC's shall communicate via native LonTalk protocol and be compatible with the LONMARK® standards. Provide a minimum of 4MB Random Access Memory in each PEC.
- C. The PEC must communicate peer-to-peer with the all of the network configurable and programmable controllers sharing alarming and scheduling information.
- D. Programming of the PEC shall be accomplished by using graphical software that incorporates drag and drop capabilities. The PEC software database must be able to execute all of the specified mechanical system controls functions. The programming software shall be able to bundle software logic to simplify control sequencing. All values, which make up the PID output value, shall be readable and modifiable at a workstation or portable service tool. Each input, output, or calculation result shall be capable of being shared/bound with any controller or interface device on the network.
- E. PEC's shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

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1. A single process shall be able to incorporate measured or calculated data from any and all other PEC's on the network. In addition, a single process shall be able to issue commands to points in any and all other PEC's or Configurable Controllers (CC) on the LonTalk network.
 2. Processes shall be able to generate operator messages and advisories to operator I/O devices.
- F. Each PEC shall support firmware upgrades without the need to replace hardware.
- G. Each PEC shall continuously perform self-diagnostics, which include communication diagnosis and diagnosis of all components.
- H. In the event of the loss of normal power, there shall be an orderly shutdown of all PEC's to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours.
1. Upon restoration of normal power, the PEC shall automatically resume full operation without manual intervention.
 2. All PEC's control programming and databases must be stored in Flash memory, therefore eliminating data loss, downtime, and re-load time.
- I. Provide a separate PEC for each AHU or other HVAC system. All system points shall reside on a single controller.

2.15 CONFIGURABLE CONTROLLERS (CC)

- A. Each Configurable Controller (CC) shall operate as a stand-alone LonMark® compliant controller capable of performing its specified control responsibilities independent of other controllers in the network. Each CC shall be a minimum 16-BIT microprocessor based, multi-tasking, multi-user, real time digital control processor.
- B. Each CC's application must comply with one of the following LONMARK® interoperability profile guidelines:
1. Variable Air Volume (VAV) boxes - Profile 8502
 2. Constant Air Volume (CAV) boxes - Profile 8502
 3. Fan Coil Units - Profile 8501
 4. Heat Pumps - Profile 8503
 5. Unit Ventilators - Profile 8505
 6. VAV AHU - Profile 8610
 7. Talon Display - Profile 8500
 8. Programmable Thermostat Controllers - Profile 8500

AUTOMATIC TEMPERATURE CONTROLS

- C. Flash memory reloads or updating of an existing control algorithm shall be completed over the network.
- D. Network access shall be accomplished at the CC room sensor or the CC. Where applicable, system wide node access shall be available from connecting to the room sensor jack. Systems that do not have a system access jack from the room sensor shall provide a dedicated network jack next to each room sensor.
- E. Controllers shall include all inputs and outputs necessary to perform the specified control sequences. Analog and digital outputs shall be industry standard signals such as 0-10V and 3-point floating control allowing for interface to a variety of industry standard modulating actuators. The CC inputs shall consist of industry standards types such as 10K thermistor, 0-10V, 4-20mA and DI. Inputs shall be electrically isolated from outputs, communications and power. All inputs shall be provided with an auto-calibrate function to eliminate sensing errors.
- F. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the network is not acceptable.
- G. The CC must be mounted remotely from the room sensor. CC's, that are wall mounted with integral room sensors, are not acceptable.
- H. The control program shall reside in the CC. The application program configuration information shall be stored in non-volatile memory with no battery backup.
- I. After a power failure the CC must run the control application using the current setpoints and configuration. Reverting to default or factory setpoints are not acceptable.
- J. The CC design must support pre-wiring of the hardware components where the electronics are not exposed to the harsh construction phase environment.
- K. The CC design must also support an integrated controller/actuator design for the VAV/CV zone level installations where the controller processing and I/O are contained within a single 3-point floating actuator housing.
- L. Programmable Communicating Thermostat (PCT). Must be available with and without scheduling capability with a menu-driven, back-lit LCD display. The PCT must have the ability to perform configuration directly at the thermostat, through the usage of a concealed button or via the network. Must contain two (2) digital inputs, and, depending on the model, up to three (3) remote sensor inputs must be available. All models with scheduler must contain a SPST auxiliary switch, which can be used to control lighting or disable the economizer function. The PCT must be capable of communicating via either native LonTalk or native BACnet.

2.16 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Mozilla FireFox™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the FMCS, shall not be acceptable.
- C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- D. The Web browser client shall support at a minimum, the following functions:
 - 1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - 2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
 - 3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - 4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
 - 5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
 - 6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

- b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - c. View logs and charts.
 - d. View and acknowledge alarms.
 - e. Setup and execute SQL queries on log and archive information.
7. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- E. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.17 MODBUS SYSTEM INTEGRATION

- A. The Network Area Controller shall support the integration of device data from Modbus RTU, ASCII, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS485, or Ethernet IP as required by the device.
- B. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the FPMS. Objects provided shall include at a minimum:
 - 1. Read/Write Modbus AI Registers
 - 2. Read/Write Modbus AO Registers
 - 3. Read/Write Modbus BI Registers
 - 4. Read/Write Modbus BO Registers
- C. All scheduling, alarming, logging, and global supervisory control functions, of the Modbus system devices, shall be performed by the Network Area Controller.
- D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.18 OPC SYSTEM INTEGRATION

- A. The Network Area Controller shall act as an OPC client and shall support the integration of device data from OPC servers. The connection to the OPC server shall be Ethernet IP as required by the device. The OPC client shall support third

party OPC servers compatible with the Data Access 1.0 and 2.0 specifications.

- B. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the OPC system data into the BAS. Objects provided shall include at a minimum:
 - 1. Read/Write OPC AI Object
 - 2. Read/Write OPC AO Object
 - 3. Read/Write OPC BI Object
 - 4. Read/Write OPC BO Object
 - 5. Read/Write OPC Date/Time Input Object
 - 6. Read/Write OPC Date/Time Output Object
 - 7. Read/Write OPC String Input Object
 - 8. Read/Write OPC String Output Object
- C. All scheduling, alarming, logging, and global supervisory control functions, of the OPC system devices, shall be performed by the Network Area Controller.
- D. The FMCS supplier shall provide a OPC client communications driver. The equipment system vendor that provided the equipment utilizing OPC shall provide documentation of the system's OPC server interface and shall provide factory support at no charge during system commissioning.

2.19 GRAPHICAL USER INTERFACE COMPUTER HARDWARE (DESKTOP)

- A. The browser workstation shall be an Intel Pentium based computer (minimum processing speed of 2.4 Ghz with 1.0 GB RAM and a 100-gigabyte minimum hard drive). It shall include a DVD-ROM/CD-RW Combination Drive, one (1) parallel port, one (1) asynchronous serial ports and two (2) USB ports. A minimum 17 inch flat panel color monitor, 1280 x 1024 optimal preset resolutions, 25 ms response time, shall also be included.
- B. Connection to the FMCS network shall be via an Ethernet network interface card, 10/100 Mbps.

2.20 CONTROLLERS

- A. General. Network Application Controller (NAC), Interoperable Digital Controller (IDC), Configurable Controller (CC), Programmable Equipment Controllers (PEC), and Programmable Communicating Thermostats (PCT) as required to achieve specified performance. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard LonTalk specification, or BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L unless otherwise specified. Hardwired actuators and sensors may be used in lieu of LonMark CC, or BACnet Smart Actuators and Smart Sensors.

- B. Communication.
1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
 2. Signal Management. NAC, IBC, PEC, CC, and PCT operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
 3. Data Sharing. Each NAC and IBC shall share data as required with each networked NAC and IBC.
 4. Stand-Alone Operation. Each piece of equipment specified shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

2.21 INPUT AND OUTPUT INTERFACE

- A. General. Hard-wire input and output points to NACs, IBCs, PECs, CCs, or PCTs.
- B. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA, and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.
- C. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to ten (10) pulses per second.
- D. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- E. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Analog outputs shall not drift more than 0.4% of range annually.
- F. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two (2) coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

- G. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.22 POWER SUPPLIES AND LINE FILTERING

- A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to eighty percent (80%) of rated capacity.
 - 1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be one percent (1%) line and load combined, with one hundred (100) microsecond response time for fifty percent (50%) load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand one hundred fifty percent (150%) current overload for at least three (3) seconds without trip-out or failure.
 - a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA listed.
- B. Power Line Filtering.
 - 1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
 - a. Dielectric strength of 1000 V minimum.
 - b. Response time of ten (10) nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.
 - d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:
 - 1. Coordination between this Contractor and all other trades, Owner, local authorities and the design team.

2. Scheduling of manpower, material delivery, equipment installation and checkout.
3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD or Visio for project co-ordination and as-built drawings.
4. Coordination/Single point of contact.

3.2 INSTALLATION METHODS

- A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division-16 sections of these specifications.
- B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.
- C. All exposed wiring, low and line voltage subject to mechanical damage, shall be run in conduit. Line and low voltage wiring shall be run in separate conduits. Concealed but accessible wiring, except in mechanical rooms and areas where other conduit and piping are exposed shall run in UL plenum rated cable as approved by local codes unless expressly restricted by requirements in Division 16 specification.
- D. All Controllers, Relays, Transducers, etc., required for stand-alone control shall be housed in a NEMA 1 enclosure with a lockable door.

3.3 SYSTEM ACCEPTANCE

- A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.
- B. Field Equipment Test Procedures: DDC control panels shall be demonstrated via a functional end-to-end test. Such that:
 1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.
 2. All analog input channels shall be verified for proper operation.

3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
 4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
 5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
 6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.
- C. As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply six (6) complete 11x17 as-built drawing sets, together with AutoCAD or Visio diskettes to the Owner.
- D. Operation and Maintenance Manuals: Submit three (3) copies of operation and maintenance manuals. Include the following
1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
 2. An operator's manual that will include detailed instructions for all operations of the system.
 3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
 4. A programmer's manual that will include all information necessary to perform programming functions.
 5. Flow charts of the control software programs utilized in the DDC system.
 6. Flow charts of the custom software programs utilized in the DDC system as approved.
 7. Complete program listing file and parameter listing file for all programs.
 8. A copy of the warranty.
 9. Operating and maintenance cautions and instructions.
 10. Controls contractor shall submit directly to the customer management the highest level administrative password. This password shall not have any restrictions at any level or operation and allow full access to the system.

3.4 TRAINING

- A. Contractor shall provide to the engineer a customized training class outline that is based upon the sites system layout prior to any scheduled training. On-site pre-canned training classes are not acceptable.
- B. Factory trained control engineers and technicians shall provide training sessions for the Owner's personnel.

- C. The control contractor shall conduct two (2) eight-hour training courses for the designated Owner's personnel in the maintenance and operation of the control system. One (1) class shall be given upon system acceptance and the other approximately six (6) months into the warranty.
- D. The course shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
 - 1. HVAC system overview.
 - 2. Operation of Control System
 - 3. Function of each Component
 - 4. System Operating Procedures
 - 5. Programming Procedures
 - 6. Maintenance Procedures

3.5 WARRANTY

- A. The control system shall be warranted to be free from defects in both material and workmanship for a period of one (1) year of normal use and service. This warranty shall become effective the date the Owner accepts or receives beneficial use of the system.

PART 4 - SEQUENCE OF OPERATION

4.1 GENERAL

- A. All HVAC Systems shall be controlled with Direct Digital Control (DDC) according to the sequence of operation contained in this section of the specifications. Additional points or software programming not listed but which are required to meet the following sequences of operation shall be provided.
- B. Mechanical Contractor shall coordinate with Equipment Manufacturers and Temperature Controls Contractor to provide all necessary components required for communication between Mechanical Equipment and Temperature Control System.

4.2 DEDICATED OUTDOOR AIR SYSTEM, (no cooling) – AHU-1, 2

- A. Occupied Mode: The DOAS unit shall be indexed to run during occupied hours or by a special event schedule for the respective area. The supply and exhaust fans shall run continuously and the outside and exhaust dampers shall be open. A differential pressure switch across the filter banks shall indicate an alarm if the filters become dirty and create a differential pressure of > 1.0inwc (adjustable). The supply and exhaust fans shall be monitored by a current sensing switch and generate an alarm if either fan fails. Discharge air setpoint shall be reset by the

average space temperature of the space it is serving.

- B. Occupied Heating: The enthalpy wheel speed shall be modulated to maintain the enthalpy wheel discharge setpoint as determined by the discharge air setpoint. If further heating is required the hot water valve shall modulate to maintain discharge air setpoint.
- C. Unoccupied Mode: The air handling unit shall be indexed to off during unoccupied hours by the DDC controller. The supply fan shall be off and the outside and exhaust dampers shall be closed.
- C. Defrost Sequences are to be supplied by the manufacturer for BMS system implementation.
- D. Smoke Detector Shutdown: Duct smoke detectors shall be provided on the supply side of the ductwork and shall shut the unit down upon detection of smoke in the system.

4.3 DEDICATED OUTDOOR AIR SYSTEM, (no cooling) – AHU-7, 9

- A. Occupied Mode: The DOAS unit shall be indexed to run during occupied hours or by a special event schedule for the respective area. A differential pressure switch across the filter banks shall indicate an alarm if the filters become dirty and create a differential pressure of > 1.0 inwc (adjustable). The supply and exhaust fans shall be monitored by a current sensing switch and generate an alarm if either fan fails.
- B. Occupied Heating: The supply fan shall run continuously at a minimum airflow (adjustable) to maintain the occupied mode heating setpoint. The hot water valve on the supply shall modulate to maintain the space temperature setpoint. The exhaust fan, bypass damper and energy wheel shall remain off subject to input from the CO₂ sensor. The supply fan, return fan and bypass damper shall modulate based on input from a CO₂ sensor. As the amount of people in the space increases, as sensed by the CO₂ sensor, the fan speeds shall increase and the bypass damper shall modulate accordingly.
- C. Occupied Cooling (AHU-7, alternate): The supply fan, exhaust fan, bypass damper and energy wheel shall follow a similar sequence to that of occupied heating. The compressors shall stage individually, upon a call for cooling to maintain the occupied mode cooling setpoint. Cooling shall be disabled in the unoccupied mode.
- C. Unoccupied Mode: The DOAS unit shall be indexed to off during unoccupied hours by the DDC controller. The supply fan shall be off and the outside and exhaust dampers shall be closed. Upon a call for heating the supply fan shall activate and the hot water valve shall modulate to maintain the unoccupied mode space temperature.

- D. Defrost Sequences are to be supplied by the manufacturer for BMS system implementation.
- E. Smoke Detector Shutdown: Duct smoke detectors shall be provided on the supply side of the ductwork and shall shut the unit down upon detection of smoke in the system.

4.4 RADIATION AND CONVECTORS

- A. Occupied: Each space temperature sensor shall open/close the associated radiation valve to maintain the adjustable occupied set point.
- B. Unoccupied set point shall be 57°F (adjustable).

4.5 Air Handling Units with Hot Water Coils and D/X Cooling – AHU-4, 5, 6, 9

- A. Smoke Detector Shutdown: The supply duct mounted smoke detectors upon sensing products of combustion shall, through a hardwired interlock to their respective starter or emergency shutdown terminals on a packaged unit, shall shut down any associated fans.
- B. Freeze Protection: The Freeze Protection thermostat mounted on the leaving side of the heating coil shall shutdown the supply fan and associated exhaust fan if the temperature drops below 38°F. During this condition the heating coil valve shall go to full open and the outside air damper shall move to full closed position. An alarm shall be initiated through the BAS.
- C. Filter Alarms: A differential pressure switch across the unit's filters and wired to the BAS control panel shall when the filters become dirty initiated an alarm through the BAS.
- D. Supply Fan Alarm: If the supply fan does not start as determined by the current sensing relay an alarm shall be initiated to the BAS.
- E. Optimum Start: Each RTU shall have an optimum start program that will index the unit into warm-up or cool down mode based on the time needed to bring the indoor conditions to their specified set points by its scheduled start time.
- F. Occupied Cooling: The supply fan shall remain running. The outside air, return air and exhaust air dampers shall be in the closed position. If the return air enthalpy is greater than the outside air enthalpy, the outside air and return air dampers shall modulate to provide free cooling. If additional cooling is required the DX cooling stages shall begin to modulate to maintain the discharge air setpoint as reset by the average space temperature. As the discharge air temperature setpoint is met, the DX cooling stages shall modulate off before the

outside air and return air dampers begin to close. If outside air enthalpy is greater than return air enthalpy then the outside air and return air dampers shall remain at minimum ventilation position and DX cooling shall be staged to provide cooling.

- G. Occupied Heating: The supply and return fans shall remain running. The outside air damper shall remain closed subject to modulation by the CO2 controls. The hot water valve shall modulate to maintain the discharge air set point as reset by the average space temperature.
- H. Energy Wheel (as specified): The energy wheel shall run anytime the outside air dampers are open at minimum or greater except when in economizer mode.
- I. CO2 Control: The return air CO2 sensor shall monitor the CO2 concentration and modulate the economizer dampers to maintain CO2 setpoint (adjustable). Damper shall modulate between fully closed and max outside air cfm as listed on the drawings (position to be set by the balancing contractor).
- J. Shutdown Periods: Unoccupied Cooling & Unoccupied Heating: When the supply fans are shut down, outside air dampers shall be closed, return air dampers shall be opened, the DX cooling shall be off and the heating coil valve shall be opened. In heating, if any space temperature drops below 55°F (adjustable) the respective unit shall be indexed to warm-up and shall operate per the warm-up sequence described within. When the space temperature rises 5°F the unit shall return to the unoccupied sequence and shutdown.

4.6 Heating and Ventilating Units

- A. Freeze Protection: The Freeze Protection thermostat mounted on the leaving side of the heating coil shall shutdown the supply fan and associated exhaust fan if the temperature drops below 38°F. During this condition the heating coil valve shall go to full open and the outside air damper shall move to full closed position. An alarm shall be initiated through the BAS.
- B. Filter Alarms: A differential pressure switch across the unit's filters and wired to the BAS control panel shall when the filters become dirty initiated an alarm through the BAS.
- C. Supply Fan Alarm: If the supply fan does not start as determined by the current sensing relay an alarm shall be initiated to the BAS.
- D. Occupied Heating: The supply fan shall remain running. The outside air damper remains open. The hot water valve shall modulate to maintain the discharge air setpoint as reset by the average space temperature.
- E. Unoccupied Heating: When the supply fans are shut down, the outside air dampers shall be closed, the heating coil valve shall be open. Upon a call for

heating the supply fan shall start and the hot water valve shall modulate to maintain the unoccupied mode space temperature schedule.

4.7 EXHAUST FANS; (EF-1, 2, 3, 4, 4A, 5, 6, 7, 10, 11, 12, 13, 16, 17)

- A. Shall run based on the respective area occupied schedule.
- B. The fans shall have proof of running via a current sensing relay; if any fan fails an alarm shall be generated to the BMS upon any failure.

4.8 Science Storage Exhaust Fan; (EF-22)

- A. Shall run continuously.
- B. The fans shall have proof of running via a current sensing relay; if any fan fails an alarm shall be generated to the BMS upon any failure.

4.9 EXHAUST FANS; (EF-9, 14, 15, 18, 19, 20)

- A. Shall be activated by a local switch. Local switch by Electrical Contractor.

4.10 Boiler Room Operation

- A. If outside air is less than 65° F(adjustable) then the boiler system shall be indexed to heating. Once in the heating mode the lead hot water pump shall start and shall begin to speed up to maintain system differential pressure setpoint which is to be determined by the balancing contractor. If the lead hot water pump fails as determined by the current reading, faults and alarms from the VFD then the lag hot water pump shall start and run as the lead. An alarm shall be initiated through the BMS.

On a call for heating the combustion air fan shall start and once running as determined by a current sensor, the lead boiler shall be enabled to run. The BMS shall calculate outside air reset based upon the table below and send the reset setpoint to this boiler. All communications to this boiler shall be via the lonWorks network connection. Through this connection the BMS shall also monitor all available temperatures, status', alarms and report this information to the graphical pages.

If the lead boiler fails or if it is unable to maintain the hot water setpoint, then the secondary boiler shall be enabled to run. If the secondary boiler is unable to maintain the hot water setpoint the third boiler shall be enabled to run. All boilers shall be modulated through the BMS to maintain the hot water reset setpoint as described earlier in this sequence. All alarms shall be monitored and reported through the BMS.

All above sequences are with propane as the fuel source.

When boiler is running the delta temperature between the boiler supply and boiler return shall be monitored. If the delta T exceeds 40°F, the respective blend pump shall start and circulate supply water to the return to prevent thermal shock. When the building return water temp increases so the delta T is less than 40°F, then the respective blend pump will shutdown.

C. Outside Air Reset Schedule as Follows:

Outside Air Temp	Boiler set point
65°F	140°F
20°F	180°F

E. All alarms shall be sent to designated personnel.

4.11 Kitchen Equipment

- A. Makeup air unit: System shall be activated subject to activation of any kitchen exhaust fan. Supply fan shall activate and outside air damper shall open. Burner shall activate to maintain space neutral (75F, adjustable, discharge air temperature.)
- B. Kitchen exhaust fans (KEF-1, KEF-2, CEF-1): Fans shall activate subject to local control. The fans shall have proof of running via a current sensing relay; if any fan fails an alarm shall be generated to the BMS upon any failure.
- C. Smoke detector shutdown: Smoke detector shall be supplied in supply air ductwork and shall shut down unit and kitchen exhaust fans upon detection of smoke.

4.12 Ductless Split Systems

- A. Systems shall be provided with manufacturer's controls.
- B. Controls contractor shall provide space temperature sensor and monitor via BMS system.

4.13 Unit Heaters and Cabinet Unit Heaters

- A. The fan shall cycle on/off to maintain space temperature setpoint subject to hot water being available as determined by the aqua-stat located on unit heater piping. If outside air is above 60° F. the unit heaters shall be locked out.

4.14 Radon Exhaust Fans

- A. Radon exhaust fans shall run continuously. Fan status shall be monitored on BMS.

- B. Fan pressure sensors shall signal alarm to BMS on drop in pressure to indicate fan failure.

PART 5 - APPENDIX A

5.1 FIELD DEVICES: Provide automatic control valves, automatic control dampers, thermostats, clocks, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer.

A. Temperature Sensors (Siemens, ACI or Veris)

1. Temperature Sensors: Temperature sensors shall be linear precision elements with ranges appropriate for each specific application.
2. Space (room) sensors shall be available with setpoint adjustment and override switch for all common areas (ie. Gym, café, media, admin offices and etc.). The set point slide adjustment shall have software limits by the automation system to limit the amount of temperature setpoint adjustment. Space sensor housing shall be constructed with ventilation slots to provide adequate airflow the ambient air space being measured.
3. Duct mounted averaging sensors shall incorporate a 2x4 electrical conduit box housing, and utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacture recommendation and looped and fastened at a minimum of every 36 inches.
4. Duct mounted point sensors shall incorporate a 2x4 electrical conduit box housing.
5. Sunshields shall be provided for outside air sensors.
6. Thermo-wells for all immersion sensors shall be stainless steel or brass as required for the application.

B. Humidity Sensors (Siemens, ACI or Veris): Humidity sensors shall be of the solid-state type using a capacitance-sensing element. The sensor shall vary the output voltage with a change in relative humidity. Room humidity sensors shall have a minimum range of ten to ninety percent (10-90%) plus or minus five percent ($\pm 5\%$). Supply air humidity sensors shall have a range of ten to ninety percent (10-90%) plus or minus five percent ($\pm 5\%$). Space humidity sensor housings shall be constructed with ventilation slots to provide adequate airflow from the ambient air space being measured.

C. Air Velocity Sensors (Siemens, ACI or Veris): The sensor shall use differential pressure to determine airflow rate and have repeatability within one percent (1%) of reading and an accuracy of plus or minus five percent ($\pm 5\%$) of range. The velocity

range shall be from 0 to 3250 FPM.

- D. Pressure Sensors (Siemens, ACI or Veris): The differential pressure sensor shall be temperature compensated and shall vary the output voltage with a change in differential pressure. Sensing range shall be suitable for the application with linearity of one and one half percent (1.5%) of full scale and offset of one percent (1%) of full scale or better. Sensor shall be capable of withstanding up to one hundred fifty percent (150%) of rated pressure without damage.
- E. Air Quality Sensor (Siemens, ACI or Veris): The air quality sensor shall be capable of simultaneously monitoring various types of Volatile Organic Compounds (VOCs). The sensor shall be capable of monitoring from one hundred percent (100%) air quality to zero percent (0%) air quality and shall produce a linear 0-10 VDC signal. The Air Quality Sensor shall be provided in wall or duct mounted models, as shown on the plans.
- F. Occupancy/CO2 Sensor (Siemens, ACI or Veris). The sensor shall be capable of monitoring from CO2 concentration in a space at an accuracy of +/- 100 parts per million (PPM). The CO2 sensor shall produce a linear 0-10 VDC signal over the range of 0 to 2000 PPM. The CO2 sensor shall be measure using photo-acoustic technology, such that no "break-in period be needed to establish a CO2 concentration baseline to accurately measure the space. The CO2 sensor shall be provided in wall or duct mounted models, as shown on the plans.
- G. Switches and Thermostats (Siemens, Kele or Veris)
 - 1. The FMCS Contractor shall furnish all electric relays and coordinate with the supplier of magnetic starters for auxiliary contact requirements. All electric control devices shall be of a type to meet current, voltage, and switching requirement of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.
 - 2. Duct Smoke Detectors: Duct smoke detectors shall be supplied by others with an integral auxiliary contact to be used by the FMCS contractor to provide a digital input to the FMCS.
 - 3. Low Temperature Detection Thermostats: Shall be the manual reset type. The thermostat shall operate in response to the coldest 1 foot length of the 20-foot sensing element, regardless of the temperatures at other parts of the element. The element shall be properly supported to cover the entire downstream side of the coil with a minimum of three loops. Separate thermostats shall be provided for each 25 square feet of coil face area or fraction thereof.
 - 4. Differential Pressure Switches: Pressure differential switches shall have SPDT changeover contact, switching at an adjustable differential pressure setpoint.
 - 5. Current Sensing Relays: Motor status indications, where shown on the plans, shall be provided via current sensing relays. The switch output contact shall be rated for 30 VDC, .15 amps.
 - 6. Flow Switches: Motor status indications, where shown on the plans, shall be

provided via flow switches. Flow switches shall be of the paddle type equipped with SPDT contacts to establish proof of flow.

H. Automatic Control Valves

1. Manufacturers: Siemens Building Technologies or approved equal.
2. Provide automatic control valves suitable for the specified controlled media of the type and general construction indicated. Where type or general construction is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on controlled media, maximum pressure and temperature rating of piping system, and other pertinent application requirements. Unless otherwise indicated, provide valves which mate and match material of connecting piping. Provide equipment control valves with control valve actuators of required input power type and control signal type that will accurately position the flow control element and provide sufficient force to achieve required leakage specification.

a. Distribution Valves

1) Flanged Valves, line size 2½ to 6 inches

a) Controlled Media Specific Items

- (1) Water: The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

b) General Construction Materials/Applicable Standards

- (1) Pressure Class 125: Control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 125.
- (2) Pressure Class 250: Control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.
- (3) Flange Connection Dimensions: For Class 125 and Class 250 valve assemblies, flange dimensions shall be according to ANSI B16.1, and valve body

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flange-to-flange dimensions shall be according to ANSI/ISA S75.03.

- (4) Flow Rate (Cv): The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
- (5) Equal Percentage Flow Characteristic: The control valve shall have a modified equal percentage flow characteristic.
- (6) Range Ability: The control valve shall have a minimum range ability of 100:1.
- (7) Leakage Class IV (0.01%): Valve shall meet the requirements of seat leakage Class IV according to ANSI/FCI 70.2, with no more than one hundred twenty five percent (125%) of nominal force necessary to balance fluid forces applied to valve stem.
- (8) Chilled and Hot Water Packing: Valve stem packing shall be of a cartridge type and shall contain at least two (2) EPDM o-rings.
- (9) Bronze Trim: Control valve seat shall be made of stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400.
- (10) Stainless Trim: Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.
- (11) Stem Materials: Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

c) Service Parts

(1) Packings

- (a) Chilled and Hot water Packing: Valve stem packing shall be of a cartridge type and shall contain at least two (2) EPDM o-rings. The cartridge type packing shall be replaceable as a unit.

(2) Trim

- (a) Plug and Stem: The control plug and stem shall be replaceable as a unit.

2) Threaded Valves, line size ½ inch to 2 inches

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- a) Controlled Media Specific Items
 - (1) Water: The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

- b) General Construction Materials/Applicable Standards
 - (1) Pressure Class 250: Control valve bodies shall be constructed of cast bronze according to UNS C84400, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.
 - (2) Threaded Connection Dimensions: Threaded connection specifications shall be according to ANSI B2.1.
 - (3) Flow Rate (Cv): The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
 - (4) Equal Percentage Flow Characteristic: The control valve shall have a modified equal percentage flow characteristic.
 - (5) Range Ability: The control valve shall have a minimum range ability of 100:1.
 - (6) Leakage Class IV (0.01%): Valve shall meet the requirements of seat leakage Class IV according to ANSI/FCI 70.2, with no more than one hundred twenty-five percent (125%) of nominal force necessary to balance fluid forces applied to valve stem.
 - (7) Chilled and Hot Water Packing: Valve stem packing shall be of a cartridge type and shall contain at least two (2) EPDM o-rings.
 - (8) Bronze/Brass Trim: Control valve seat shall be made of stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400 and/or brass according to UNS C36000.
 - (9) Stainless Trim: Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.
 - (10) Stem Materials: Valve stem shall be made of polished stainless steel according to ASTM A581/A

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or ASTM A582/A.

- c) Service Parts
 - (1) Packings
 - (a) Chilled and Hot water Packing: Valve stem packing shall be of a cartridge type and shall contain at least two (2) EPDM o-rings. The cartridge type packing shall be replaceable as a unit.
 - (2) Trim
 - (a) Plug and Stem: The control plug and stem shall be replaceable as a unit.

- b. Terminal Unit Valves

- 1) Threaded Valves, line size ½ inch to 1½ inches
 - a) Controlled Media Specific Items
 - (1) Water: The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.
 - b) General Construction Materials/Applicable Standards
 - (1) Pressure Class 250: Control valve bodies shall be constructed of cast bronze according to UNS C84400, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.
 - (2) Threaded Connection Dimensions: Threaded connection specifications shall be according to ANSI B2.1.
 - (3) Flow Rate (Cv): The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
 - (4) Modified Equal Percentage Flow Characteristic: The control valve shall have a modified equal percentage flow characteristic, according to ANSI/ISA S75.11.
 - (5) Range Ability: The control valve shall have a

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minimum range ability of 100:1 on valves with a Cv value greater than or equal to 1.0 and a minimum range ability of 50:1 on valves with a Cv value less than 1.0.

- (6) Leakage Class IV (0.01%): Valve shall meet the requirements of seat leakage Class IV according to ANSI/FCI 70.2, with no more than one hundred twenty-five percent (125%) of nominal force necessary to balance fluid forces applied to valve stem.
- (7) Chilled Water and Hot water Packing: Valve stem packing shall contain at least two (2) EPDM o-rings.
- (8) Bronze/Brass Trim: Control valve seat and plug shall be made of bronze according to UNS C84400 and/or brass according UNS C36000.

c. Zone Valves

- 1) Threaded or Sweat Connection Valves, line size ½ to 1 inch
 - a) Controlled Media Specific Items
 - (1) Water: The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 230°F (110°C).
 - b) General Construction Materials/Applicable Standards
 - (1) Pressure Class 125: Control valve bodies shall be constructed of forged brass and shall meet requirements of ANSI B16.1, pressure class ANSI 125.
 - (2) Threaded Connection Dimensions: Threaded connection specifications shall be according to ANSI B2.1.
 - (3) Sweat Connection Dimensions: Sweat connection specifications shall be according to ANSI B16.22.
 - (4) Flow Rate (Cv): The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
 - (5) Leakage Class III (0.1%): Valve shall meet the requirements of seat leakage Class III according to ANSI/FCI 70.2, with no more than one hundred twenty-five percent (125%) of nominal force necessary to balance fluid forces applied to valve

stem.

- (6) Chilled and Hot Water Packing: Valve stem packing shall contain at least two (2) EPDM o-rings.
- (7) Brass Trim: Control valve seat and plug shall be made of brass according UNS C36000.

d. Ball Valves

1) Threaded Valves, line size ½ inch to 2 inches

a) Controlled Media Specific Items

- (1) Water: The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C).

b) General Construction Materials/Applicable Standards

- (1) Body Material: Control valve bodies shall be constructed of forged brass according to ASTM B283, and shall meet requirements of no less than 360 PSI at 250°F.
- (2) Ball Material: Valve ball shall consist of chemically nickel-plated brass. Manufacturer shall provide a glass filled polymer ball insert, as an integral part of the ball, for modulating flow applications.
- (3) Threaded Connection Dimensions: Threaded connection specifications shall be according to ANSI B2.1.
- (4) Flow Rate (Cv): The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
- (5) Equal Percentage Flow Characteristic: The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11.
- (6) Leakage Class IV (0.01%): Valve shall meet the requirements of seat leakage Class IV according to ANSI/FCI 70.2, with no more than one hundred twenty-five percent (125%) of nominal force necessary to balance fluid forces applied to valve stem.
- (7) Chilled and Hot Water Packing and Stem: Valve shall have a blow-out proof stem with two (2) EPDM O-rings.
- (8) Stem Materials: Valve stem shall be made of brass.

- (9) Manual Operation: Valve shall have the ability to be manually operated in the event of a power failure.

I. Electronic Valve Actuators

- 1. Manufacturers: Siemens Building Technologies or approved equal.

- a. General Requirements

- 1) Applicable Standards

- a) The valve actuator shall be identified as a Class 2 operating device, according to NEC, Article 725.
 - b) The valve actuator shall be tested and listed by Underwriters Laboratories according to UL873, and shall bear the UL and cUL approval symbols.
 - c) The valve actuator shall be designed and tested to NEMA 1 standards according to NEMA 250.

- b. Distribution Valve Actuators

- 1) Direct Coupled

- a) The control valve actuator shall be directly coupled to the valve, with no intermediary linkage kit required, to facilitate repair and/or replacement.
 - b) The control valve actuator shall be equipped with a manual override feature, allowing operation of the control valve upon loss of control power or signal, without the aid of a separate tool or auxiliary power supply.

- 2) Fail Safe Operation: Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.

- 3) Visual Position Indication: The valve actuator shall provide indication of valve stem position, clearly visible from a distance of 15ft.

- c. Terminal Unit Valve Actuators

- 1) Direct Coupled

- a) The control valve actuator shall be directly coupled to the valve, with no intermediary linkage kit required, to facilitate repair and/or replacement.
 - b) The control valve actuator shall be equipped with a

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manual override feature, allowing operation of the control valve upon loss of control power or signal, without the aid of a separate tool or auxiliary power supply.

- 2) Fail Safe Operation: Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.
- 3) Visual Position Indication: The valve actuator shall provide indication of valve stem position, clearly visible from a distance of 15ft.

d. Zone Valve Actuators

1) Direct Coupled

- a) The control valve actuator shall be directly coupled to the valve, with no intermediary linkage kit required, to facilitate repair and/or replacement.
- b) The control valve actuator shall be equipped with a manual override feature, allowing operation of the control valve upon loss of control power or signal, without the aid of a separate tool or auxiliary power supply.

- 2) Fail Safe Operation: Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.
- 3) Visual Position Indication: The valve actuator shall provide indication of valve stem position, clearly visible from a distance of 15ft.

e. Ball Valve Actuators

1) Direct Coupled

- a) The control valve actuator shall be directly coupled to the ball valve stem to facilitate repair and/or replacement.
- b) The control valve actuator shall be equipped with a manual override feature, allowing operation of the control valve upon loss of control power or signal.

- 2) Fail Safe Operation: Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.
- 3) Torque Requirement: The control valve actuator shall provide minimum torque required for full valve shutoff position.

J. Damper Actuators

1. Manufacturers: Siemens Building Technologies or approved equal
 - a. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
 - b. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "V" shaped toothed cradles; each having two (2) rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
 - c. All actuators having more than a 100 lb-in torque output shall accept a 1 inch diameter shaft directly, without the need for auxiliary adapters.
 - d. All actuators having more than 100 lb-in torque output shall have an all metal housing made from die-cast aluminum.
 - e. All actuators must provide overload protection throughout the full range of rotation, enabling the actuator to detect a blockage in the damper and withstand a continuous stall condition without premature failure, or degradation in performance.
 - f. All spring return actuators shall be capable of both clockwise or counterclockwise spring return fail-safe operation.
 - g. All spring return actuators shall use a continuously engaged mechanical return spring that returns the actuator to a fail-safe position within fifteen (15) seconds, under rated temperature and load, in response to a loss of power. Other fail-safe mechanisms which are either engaged only in response to a loss of power, or which are non-mechanical are not acceptable.
 - h. All actuators shall provide a means of manually positioning the output coupling in the absence of power.
 - i. Dual independently adjustable auxiliary switches must be integral to the actuator, thus maintaining a low total installed cost. The addition of this feature as an accessory kit is not acceptable.
 - j. All actuators having more than 100 lb-in torque shall provide a factory mounted electrical cable (3 feet) and conduit fitting, thus maintaining a low total installed cost.
 - k. All actuators shall not require more than 10 VA.
 - l. Proportional actuators shall accept a 0-10 VDC or 4-20mA control signal, and provide a 0-10 VDC feedback signal.
 - m. All actuators shall provide an easily readable high contrast yellow on black position indicator.
 - n. All actuators shall be designed for a minimum of fifty thousand (50,000) full stroke cycles at the actuator's rated torque and

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temperatures, and manufactured using ISO9002 and ISO14000 registered procedures, and shall be UL873 and CSA22.2 listed. Actuators shall be as manufactured by SIEMENS.

K. Control Dampers (Ruskin or Equal)

1. Motorized dampers, unless otherwise specified elsewhere, shall have damper frames using 13 gauge galvanized steel channel or 1/8 inch extruded aluminum with reinforced corner bracing. Damper blades shall not exceed 10 inches in width or 48 inches in length. Blades are to be suitable for high velocity performance. Damper bearings shall be as recommended by manufacturer for application. Bushings that turn in the bearing are to be oil impregnated sintered metal. All blade edges and top and bottom of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals may be spring-loaded stainless steel. The seals shall provide a maximum of one percent (1%) leakage at a wide open face velocity of 1500 FPM and 4: W.C. close-off pressure. The damper linkage shall provide a linear flow or equal percentage characteristic as required.
2. Control dampers shall be parallel or opposed blade type as scheduled on drawings or outdoor and return air mixing box dampers shall be parallel blade, arranged to direct air streams towards each other. All other dampers may be parallel or opposed blade types.

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. General Project Description:

- 1. Existing Conditions: The facility presently has two (2) liquid propane (LP) tanks with piping distribution.
 - a. Aboveground tank outside existing Kitchen serves Kitchen commercial cooking appliances.
 - b. Underground tank within well equipment building's chain link enclosure serves emergency generator also located in that enclosure.
- 2. Renovate-as-New Project Requirements: Liquid Propane service will be required for space heating boilers, domestic water heaters, commercial cooking appliances, and a makeup air unit.

B. Section Includes:

- 1. Temporary relocation (in coordination with school's present LP supplier) of existing aboveground LP tank serving existing Kitchen, to allow installation of new transformer.
- 2. Demolition and removal (in coordination with school's present LP supplier) of existing LP gas tanks and piping distribution, in coordination with project phasing.
- 3. Provision (in coordination with Owner-selected LP supplier going forward) of new LP tank farm. The supplier shall furnish and install, retain ownership and maintain the underground tank installations, including related risers and service pressure regulators (regulating tank pressure to 10 psig). The Contractor shall furnish and install all exterior aboveground and belowground gas supply piping to the building, through building's main gas shutoff valve and secondary pressure regulator (regulating 10 psig to 2 psig), located low on building wall (in locking chain link enclosure by Site Contractor), where indicated on the Plumbing Plans. Contractor's building gas distribution work begins at discharge of building main gas shutoff valve/secondary pressure regulator. Site Contractor shall be responsible for all related earthwork and enclosures, and shall coordinate and perform his work to the satisfaction of the installing LP supplier, the exterior gas piping installation contractor, and the local Fire Marshal (including enclosure access).
- 4. Contractor's work includes:
 - a. Piping specialties.
 - b. Piping and tubing joining materials.
 - c. Valves.

- d. Appliance type pressure regulators.
- e. Line type (secondary) pressure regulators.

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.
- D. Natural-gas: Liquefied petroleum gas in the vapor phase only.
- E. LP gas; LPG: Liquefied petroleum gas.

1.4 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: Primary (tank pressure to 10 psig) and secondary (10 psig to 2 psig) service regulator(s) are to be provided by the LP gas supplier.
 - 3. Required Gas Supply Pressure to the Building: 2 psig.
- B. Natural-Gas Distribution System Pressure within Building: 2 psig. Each item of equipment shall be provided with LP-gas rated and compatible appliance regulator to regulate pressure to equipment's required inlet pressure range.
- 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. Corrugated, stainless-steel tubing with associated components.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 4. Pressure regulators (appliance-type). Indicate pressure ratings and capacities.
 - 5. Dielectric fittings.
 - 6. Flow Monitors
- 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: ¼ inch per foot (1:50).
 - 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 motorized gas valves, pressure boosting equipment, pressure regulators and flow monitors 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, "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.

1.8 PROJECT CONDITIONS

- A. Perform site survey, research public and private utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Gas Service: Do not interrupt gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify General Contractor no fewer than seven (7) days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without General Contractor's written permission.

1.9 COORDINATION

- A. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083313 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
- B. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type L.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - 2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
- C. PE Pipe: ASTM D 2513, SDR 11.
 - 1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
 - 2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53, black steel, Schedule 40, Type E or S, Grade B.
 - 3. Anodeless Service-Line Risers: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
 - b. Casing: Steel pipe complying with ASTM A 53, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.

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

- a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1) Dresser Piping Specialties
 - 2) Smith-Blair, Inc.
- b. Steel flanges and tube with epoxy finish.
- c. Buna-nitrile seals.
- d. Stainless-steel bolts, washers, and nuts.
- e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

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

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

- 1. Copper-alloy convenience outlet and matching plug connector.
- 2. Nitrile seals.
- 3. Hand operated with automatic shutoff when disconnected.
- 4. For indoor or outdoor applications.
- 5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

- 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
- 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
- 3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with fifty percent (50%) free area.
- 4. CWP Rating: 125 psig.

D. Basket Strainers:

- 1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
- 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
- 3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with fifty percent (50%) free area.
- 4. CWP Rating: 125 psig.

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

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.
 - 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 - 6. Service Mark: Valves 1¼ inches to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
 - 1. CWP Rating: 125 psig.
 - 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - 3. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.
 - 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 (1) of the following:
 - a. BrassCraft Manufacturing Company; a Masco company
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyll, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated brass.

4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Separate packnut with adjustable-stem packing threaded ends.
7. Ends: Threaded, flared, or socket as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

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

2.5 MOTORIZED GAS VALVES

A. Electrically Operated (Solenoid) Valves: Comply with UL 429.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. ASCO Power Technologies, LP; Division of Emerson
 - b. Dungs, Karl, Inc.
 - c. Eclipse Combustion, Inc.
 - d. Goyen Valve Corp.; Tyco Environmental Systems
 - e. Magnatrol Valve Corporation
 - f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
 - g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
2. Pilot operated.

3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Provide with manual reset switch for remote mounting; coordinate exact location with all other trades. Location should be within the space where solenoid valve is located, but minimum 8 feet away from gas-fired appliances/equipment served by solenoid valve.

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.

B. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

C. Line (Secondary Service) Pressure Regulators: Comply with ANSI Z21.80.

1. Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Maxitrol Company
 - b. American Meter Company
 - c. Actaris
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream and not exceed one hundred fifty percent (150%) of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure Rating: at least 10 psig. (Note: Confirm final secondary service regulator's required maximum inlet pressure rating with LP gas supplier's tank regulator discharge pressure setting.)

D. Appliance Pressure Regulators (for reducing pressure from building distribution pressure (2 psig) to appliance inlet pressure range): Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Listed indoor regulators may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure Rating: At least 5 psig.

2.7 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Hart Industries International, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group
2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - d. Wilkins; Zurn Plumbing Products Group
2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.

4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

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 State of Connecticut Gas Equipment and Piping Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with The State of Connecticut Gas Equipment and Piping Code requirements for prevention of accidental ignition.

3.3 EARTHWORK

- A. Comply with requirements in Section 312310 "Earthwork" for excavating, trenching, and backfilling.

3.4 OUTDOOR PIPING INSTALLATION

- A. Comply with The State of Connecticut Gas Equipment and Piping Code for installation and purging of natural-gas piping.
- B. Install underground, LPG piping buried at least 36 inches below finished grade. Comply with requirements in Section 312310 "Earthwork" for excavating, trenching, and backfilling.
 1. If LPG piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Install underground, PE, LPG piping according to ASTM D 2774.
 1. Provide detectable underground warning tape for all buried gas piping.
- D. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.
- E. Install fittings for changes in direction and branch connections.
- F. When routing on flat roofs, install gas piping on MAPA MT Series or approved equal, Nylon-based, free-standing, non-penetrating adjustable roller pipe supports with neoprene base pads.

- G. Joints for connection to inlets and outlets on vaporizers, air mixers, regulators, and valves may be flanged or threaded to match the equipment.
- H. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.5 INDOOR PIPING INSTALLATION

- A. Comply with The State of Connecticut Gas Equipment and Piping 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 piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Verify final equipment locations and input/inlet pressure requirements for roughing-in.
- K. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- L. 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.
- M. Extend relief vent connections for new pressure regulators and overpressure protection devices to outdoors and terminate with weatherproof vent cap. All such terminations shall be a minimum of 25 feet away from fresh air intakes, doors, or operable windows.

- N. 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.
- O. 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. All such terminations shall be a minimum of 25 feet away from fresh air intakes, doors, or operable windows.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 - 3. 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.
 - 4. 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.
 - c. Do not directly install natural-gas piping in cast-in-place concrete floors or slabs.
- P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- Q. Connect branch piping from top or side of horizontal piping.
- R. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- S. Do not use natural-gas piping as grounding electrode.
- T. Install strainer on inlet of each appliance-pressure regulator and automatic or electrically operated valve.
- U. Install pressure gage upstream and downstream from each appliance regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping".
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC".
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC".
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC".

- Y. Comply with requirements in Division 09 painting Sections for painting interior natural-gas piping.

3.6 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.7 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

D. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches; minimum rod size, 3/8 inch.
4. NPS 1 (DN 25): Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum

3.9 CONNECTIONS

- A. Coordinate final equipment loads with LP gas supplier to assure new LP gas tank and primary service regulator installations are sufficient to supply new building gas loads and pressure requirements. Connect to LP gas supplier's tank/controls/primaryservice pressure regulator installation and extend LP gas piping (vapor state) below ground to building, and through secondary service regulator to serve building gas-consuming appliances and equipment.
- 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.

3.10 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.11 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping and as follows. For exterior natural-gas piping, provide a minimum of two (2) coats of rust-inhibiting paint, final coat yellow.

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

3.12 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to The State of Connecticut Gas Equipment and Piping 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.

3.13 OUTDOOR PIPING SCHEDULE

- A. Aboveground outdoor natural-gas piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints. Refer to Painting Article.
- B. Below ground outdoor natural-gas piping shall be the following:
 - 1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5.0 PSIG

- A. Aboveground, branch piping NPS 1 and smaller shall be one (1) of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
- B. Aboveground, distribution piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.
- B. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be the following:
 - 1. Cast-iron, lubricated plug valve.
- C. Valves in branch piping for single appliance shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.

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. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Makeup-water piping.
 - 3. Condensate drain piping.
 - 4. Air vent piping.
 - 5. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air control devices.
 - 3. Chemical treatment.
 - 4. Hydronic specialties.
- B. Shop Drawings: Detail, at 1/4 (1:50) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- C. Welding certificates.
- D. Qualification Data: For Installer.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Welding certificates.
- C. Field quality-control test reports.
- D. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 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.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
- B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.7 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 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. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Makeup-Water Piping: 80 psig at 150 deg F.
3. Condensate-Drain Piping: 150 deg F.
4. Air-Vent Piping: 200 deg F.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
- B. Wrought-Copper Fittings: ASME B16.22.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - A. Wrought-Copper Unions: ASME B16.22. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International, Inc.
 - b. Star Pipe Products.
 - c. Victaulic Company.
 2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
 3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
- B. Copper or Bronze Pressure-Seal Fittings:
 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. NIBCO INC.
 - b. Viega.
 2. Housing: Copper.
 3. O-Rings and Pipe Stops: EPDM.
 4. Tools: Manufacturer's special tools.
 5. Minimum 200-psig working-pressure rating at 250 deg F.
- C. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. T-DRILL Industries Inc.

D. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International, Inc.
 - b. Central Sprinkler Company.
 - c. Star Pipe Products.
 - d. Victaulic Company.
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Steel Pressure-Seal Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Victaulic Company.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BA9-1, silver alloy for joining copper with bronze or steel.

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

E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

G. Approved mechanical couplings shall be allowed.

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:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
 2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 2. 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.
 3. 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:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation.
 2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Perfection Corporation; a subsidiary of American Meter Company.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Victaulic Company of America.
2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.6 AIR CONTROL DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Amtrol, Inc.
 2. Armstrong Pumps, Inc.
 3. Bell & Gossett Domestic Pump; a division of ITT Industries.
 4. Taco.
- B. Manual Air Vents:
 1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Screwdriver or thumbscrew.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/8.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 225 deg F.
- C. Automatic Air Vents:
 1. Body: Bronze or cast iron.
 2. Internal Parts: Nonferrous.
 3. Operator: Noncorrosive metal float.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/4.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 240 deg F.
- D. Expansion Tanks:
 1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter.

Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.

3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

E. Replaceable Bladder-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Replaceable heavy duty Butyl rubber. Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

F. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

G. Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 deg F.

2.7 CHEMICAL TREATMENT

- A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
- B. Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

2.8 HYDRONIC PIPING SPECIALTIES

- A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

D. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

E. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller shall be the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

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- C. Makeup-water piping installed aboveground shall be the following:
 - 1. Type L drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
 - D. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
 - E. 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 the piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

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- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
 - O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
 - P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
 - Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
 - R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
 - S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
 - T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."
 - U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
 - V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Common Work Results for HVAC Piping."
 - W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Common Work Results for HVAC Piping."
 - X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Common Work Results for HVAC Piping."

3.3 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, 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. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.4 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- F. Install bypass chemical feeders in each hydronic system, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.
- G. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.5 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.6 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
 - 1. pH: 7-9.
 - 2. "P" Alkalinity: 100 to 500 ppm
 - 3. Boron: 100 to 200 ppm
 - 4. Corrosion and scale Inhibitor: 2000 ppm as total organic inhibitor
 - a. Molybdate: 200 to 300 ppm
 - b. Nitrate: 500 to 700 ppm.
- B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
- D. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:
 - 1. Hot Water Heating: 30% propylene glycol.

3.7 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

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5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

3.10 ADJUSTING

- A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.
- B. Perform these adjustments before operating the system:
1. Open valves to fully open position. Close coil bypass valves.
 2. Check pump for proper direction of rotation.
 3. Set automatic fill valves for required system pressure.
 4. Check 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. Check operation of automatic bypass valves.
 7. Check and set operating temperatures of boilers, chillers and cooling towers to design requirements.
 8. Lubricate motors and bearings.

3.11 CLEANING

- A. Flush hydronic-piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic-piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.
- B. Partial systems associated with individual (or groups) of phases of construction shall be cleaned prior to connection to infrastructure that was previously installed and cleaned. Submit reports to document cleaning procedures.

3.12 PIPE PRESSURE TEST

- A. Preparation for testing: Prepare hydronic piping in accordance with ASME 1331.a and as follows:
 - 1. Leave joints including welds uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints, which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
 - 3. Flush system with clean water. Clean strainers.
 - 4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
 - 5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
- B. Testing: Test hydronic piping as follows:
 - 1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
 - 2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the liquid.
 - 3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low-pressure filling lines are disconnected.
 - 4. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code For Pressure Piping, Building Services Piping.
 - 5. After the 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 as appropriate, and repeat hydrostatic test until there are no leaks.

END OF SECTION 232113

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.
 - 2. Close-coupled, end-suction centrifugal 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, 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.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Armstrong Pumps Inc.
 2. ITT Corporation; Bell & Gossett.
 3. TACO Incorporated.
 - 4.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line 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.
- C. Pump Construction:
 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded 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: Steel, with 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. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Permanently lubricated ball bearings.
- D. Motor: Single speed and rigidly 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 Section 230513 "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.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. American-Marsh Pumps.
 2. ITT Corporation; Bell & Gossett.
 3. 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.
- C. Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged 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: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: 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: Permanently lubricated ball bearings.
- 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 Section 230513 "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.

2.3 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:
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.
- B. Triple-Duty Valve:
1. Angle or straight pattern.
 2. 175-psig pressure rating, cast-iron body, pump-discharge fitting.
 3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
 4. Brass gage ports with integral check valve and orifice for flow measurement.

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 to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- C. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- D. Equipment Mounting:
 1. Install base-mounted pumps on cast-in-place concrete equipment bases
 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop 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. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, shutoff, and throttling valves on discharge side of pumps.
- E. Install Y-type strainer and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.
- I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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 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.
6. Start motor.
7. Open discharge valve slowly.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- C. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - 1. Thermostatic expansion valves.
 - 2. Solenoid valves.
 - 3. Hot-gas bypass valves.
 - 4. Filter dryers.
 - 5. Strainers.
 - 6. Pressure-regulating valves.

- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Shop Drawing Scale: 1/4 inch equals 1 foot.
 - 2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS**2.1 COPPER TUBE AND FITTINGS**

- A. Copper Tube: ASTM B 88, Type K.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 - 5. Seal Cap: Forged-brass or valox hex cap.
 - 6. End Connections: Socket, union, threaded, or flanged.
 - 7. Working Pressure Rating: 500 psig
 - 8. Maximum Operating Temperature: 275 deg F

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Superheat: Adjustable.
6. End Connections: Socket, flare, or threaded union.
7. Working Pressure Rating: 450 psig

- H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. Equalizer: Internal.
 7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
 8. End Connections: Socket.
 9. Throttling Range: Maximum 5 psig.
 10. Working Pressure Rating: 500 psig.
 11. Maximum Operating Temperature: 240 deg F.
- I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig.
 5. Maximum Operating Temperature: 275 deg F.
- J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.
 5. Working Pressure Rating: 500 psig.
 6. Maximum Operating Temperature: 275 deg F.
- K. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in ppm.
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 240 deg F.
- L. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated charcoal.
 4. End Connections: Socket.

5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
 2. DuPont Company; Fluorochemicals Div.
 3. Honeywell, Inc.; Genetron Refrigerants.
 4. INEOS Fluor Americas LLC.
- C. ASHRAE 34, R-134a: Tetrafluoroethane.
- D. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
- E. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Safety-Relief-Valve Discharge Piping: Copper, Type K, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-407C

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Safety-Relief-Valve Discharge Piping: Copper, Type K, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Safety-Relief-Valve Discharge Piping: Copper, Type K, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

3.4 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless, packed-angle valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

- D. Except as otherwise indicated, install diaphragm packless, packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

3.5 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 1. Shot blast the interior of piping.
 - 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.

3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- T. 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."
- U. 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."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

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

3.7 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.

D. Support multifloor vertical runs at least at each floor.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.

- c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
- d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.9 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.10 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Verify that compressor oil level is correct.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves except bypass valves that are used for other purposes.
 - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Double-wall round ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Duct Lagging Material.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

3. Seismic-restraint devices.

B. HPBS Submittals:

1. Product Data for Section 16a-38k-5(d): For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
2. Laboratory Test Reports for Section 16a-38k-5(d): For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. 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, seismic restraints, and vibration isolation.
13. Preparation for selecting hangers and supports and seismic restraints.

D. 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.

E. Welding certificates.

F. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel," for hangers and supports. AWS D1.2, "Structural Welding Code -

Aluminum," for aluminum supports. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports.
 - 3. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- 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 1-4, "Transverse (Girth) 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 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

- a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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 3-1, "Seams - Round Duct and Fittings," 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. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL SPIRAL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Lindab Inc.
 2. McGill AirFlow LLC.
 3. SEMCO Incorporated.
 4. Sheet Metal Connectors, Inc.
- 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 3-2, "Transverse Joints - Round Duct," 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. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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."
 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals,"

and Figure 3-5, "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 solid sheet steel.
- D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071 and NFPA 90A; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg F at 75 deg F (24 deg C) mean temperature.
 - 2. Insulation Thickness: 2 inches.
 - 3. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 4. Coat insulation with antimicrobial coating.
 - 5. Cover insulation with polyester film complying with UL 181, Class 1.

2.4 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. Carbon-Steel Sheets: Comply with ASTM A 1008, with oiled, matte finish for exposed ducts.
- D. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- E. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of twenty-five (25) and maximum smoke-developed index of fifty (50) when tested according to UL 723; certified by an NRTL.
 - 5. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- F. 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.
- G. Tie Rods: Galvanized steel, ¼-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

- A. Fibrous-Glass Duct Liner: K-Flex Duct Liner Gray Non-porous. Double sided, solvent free, modified acrylic adhesive with a high initial tack, high adhesive strength and resistance to humidity and ageing.
- B. Construction:
1. Adhesive : 70 g/m²
 2. Support: PES/PVA scrim
 3. Liner: PE release liner, moisture and tear resistant, easy release
- C. Comply with ASTM C534 type 2, ASTM C1534, ASTM D1056-00-2C1, ASTM C423/E795, ASTM E84, UL181, ASTM C411.
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. K-Flex USA.
 - b. Johns Manville.
 - c. Knauf Insulation.
 - d. Owens Corning.
 2. Properties:
 - a. Thermal Conductivity (K): 0.25
 - b. Density (PCF): 3-6
 - c. Water Vapor Permeability: <0.06
 - d. Water Absorption (% volume change): <0.20
 - e. Flame spread/smoke development: <25/50
- D. Shop Application of Duct 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 duct liner with at least ninety percent (90%) 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. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 DUCT LAGGING MATERIAL

- A. General: Flexible barrier material for wrapping ducts to lower break-out noise from turbulent air.
- B. Nominal Density: 1 lb/sq. ft.
- C. Thickness: 0.10 inch
- D. The barrier is barium loaded high mass, limp vinyl bonded to a reinforced aluminum foil facing one side, Under Industries model DL-10-LAG or equivalent.
- E. Sound Transmission Loss: dB

Hz	125	250	500	1000	2000	4000	STC
dB	15	19	21	29	33	37	27

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 twenty-five (25) and a maximum smoke-developed index of fifty (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.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum sixty-five percent (65%).
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum sixty percent (60%).
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.9 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2. Ductmate Industries, Inc.
 - 3. Hilti Corp.
 - 4. Kinetics Noise Control.
 - 5. Loos & Co.; Cableware Division.
 - 6. Mason Industries.
 - 7. TOLCO; a brand of NIBCO INC.
 - 8. Unistrut Corporation; Tyco International, Ltd.
- B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- C. Restraint Cables ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.
- E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. All ductwork shall be galvanized steel except as follows:
 - 1. Shower/Locker Area: Aluminum.
 - 2. Exposed ductwork including but not limited to the Gymnasium: Double Spiral.

3.2 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 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are not exposed to view, seal gaps in accordance with Section 078413 Penetration Firestopping.
- K. 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 (4) sides by at least 1½ inches. Seal gaps in accordance with Section 078413 Penetration Firestopping.
- L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers. Seal gaps in accordance with Section 078413 Penetration Firestopping.
- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

- N. Install acoustic lagging material where indicated on plans.
- O. Where ducts pass through fire-rated interior partitions the duct shall be constructed of sheet metal no less than 26 gauge and shall be continuous from the air handling appliance or equipment to the air outlet and inlet terminals.

3.3 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.

3.4 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 two percent (2%) 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 1½ inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.5 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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.

3.7 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.
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.8 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.9 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one (1) coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 2. Test the following systems:
 - a. Supply Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) of total installed duct area for each designated pressure class.
 - b. Return Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) 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 fifty percent (50%) of total installed duct area for each designated pressure class.
 - d. Outdoor Air Ducts with a Pressure Class of 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) 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. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DUCT CLEANING

A. Clean new duct systems 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 Division 23 Section "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.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
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.

3.12 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.13 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
- B. Supply Ducts:
 1. Ducts Connected to Constant-Volume Air-Handling Units:
 - a. Pressure Class: Positive 3-inch wg.
- C. Return Ducts:
 1. Ducts Connected to Air-Handling Units Pressure Class: Positive or negative 3-inch wg.
- D. Exhaust Ducts:
 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2-inch wg.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 1. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg.
- F. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel.

2. Aluminum Ducts: Aluminum.

G. Liner:

1. Non-porous, 1" thick conforming to CT High Performance Building Standards

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
- a. Velocity 1000 fpm or Lower:
- 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
- b. Velocity 1000 to 1500 fpm:
- 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two (2) vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- c. Velocity 1500 fpm or Higher:
- 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two (2) vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "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 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

- 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three (3) segments for 90-degree elbow.
- 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four (4) segments for 90-degree elbow.
- 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five (5) 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.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

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. Manual volume dampers.
2. Control dampers.
3. Fire dampers.
4. Ceiling radiation dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Flange connectors.
8. Duct silencers.
9. Turning vanes.
10. Remote damper operators.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Flexible ducts.
14. Duct accessory hardware.
15. Sound Lagging Insulation

B. Related Sections:

1. Division 28 Section "Digital, Addressable Fire Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

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

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.
- b. Manual volume damper installations.
- c. Control damper installations.
- d. Fire-damper, smoke-damper, combination fire- and smoke-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 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 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.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating..

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one (1) side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

- F. Tie Rods: Galvanized steel, ¼-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Air Balance, Inc.
 - b. METALAIRE, Inc.
 - c. Penn Ventilation Company, Inc.
 - d. Ruskin Company
- 2. Standard leakage rating, with linkage outside airstream.
- 3. Suitable for horizontal or vertical applications.
- 4. Frames:
 - a. Hat-shaped, galvanized steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel, 0.064 inch thick.
- 6. Blade Axles: Galvanized steel.
- 7. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Air Balance, Inc.
 - b. METALAIRE, Inc.
 - c. Penn Ventilation Company, Inc.

d. Ruskin Company

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Angle shaped.
 - b. Galvanized steel channels, 0.064 inch thick.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized, roll-formed steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered stainless steel
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

C. Jackshaft:

1. Size: 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:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 CONTROL DAMPERS (provided by controls contractor)

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Air Balance, Inc.
 - 2. METALAIRE, Inc.
 - 3. Penn Ventilation Company, Inc.
 - 4. Ruskin Company
- 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. Angle shaped.
 - 2. Galvanized-steel channels, 0.064 inch thick.
 - 3. Mitered and welded corners.
- D. Blades:
 - 1. Multiple blade with maximum blade width of 8 inches.
 - 2. Parallel- and opposed blade design.
 - 3. Galvanized steel.
 - 4. 0.064 inch thick.
 - 5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- E. Blade Axles: ½-inch-diameter; galvanized steel blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - 1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
 - 1. Stainless-steel sleeve.
 - 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 3. Thrust bearings at each end of every blade.

2.4 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Air Balance, Inc.
 - 2. METALAIRE, Inc.
 - 3. Penn Ventilation Company, Inc.
 - 4. Ruskin Company
- B. Type: Static; rated and labeled according to UL 555 by an NRTL.

- C. Fire Rating: 1½ hours.
- D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
 - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.5 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Air Balance, Inc.
 - 2. METALAIRE, Inc.
 - 3. Penn Ventilation Company, Inc.
 - 4. Ruskin Company
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Smoke Detector: Integral, factory wired for single-point connection.
- D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- E. Blades: Roll-formed, horizontal, interlocking 0.034-inch-galvanized sheet steel.
- F. Rated pressure and velocity to exceed design airflow conditions.
- G. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or ceiling application with factory-furnished silicone caulking.
- H. Damper Motors: Two-position action.
- I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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 and 28 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

J. Accessories:

1. Auxiliary switches for signaling.
2. Test and reset switches, damper mounted.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Air Balance, Inc.
 2. METALAIRE, Inc.
 3. Penn Ventilation Company, Inc.
 4. Ruskin Company
- B. Type: Static; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Fire Rating: 1½ hours.
- D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- E. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.
- F. Smoke Detector: Integral, factory wired for single-point connection.
- G. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- H. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

- I. Damper Motors: two-position action.
- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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.
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.
- K. Accessories:
 - 1. Auxiliary switches for position indication.

2.7 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.8 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Ductmate Industries, Inc.

2. Duro Dyne Inc.
 3. METALAIRE, Inc.
 4. SEMCO Incorporated.
 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall for ducts up to 12 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Air Balance, Inc.
 2. METALAIRE, Inc.
 3. Penn Ventilation Company, Inc.
 4. Ruskin Company
 5. Ductmate Industries. Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-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 (2) sash locks.
 - b. Access Doors up to 18 Inches Square: Two (2) hinges and two (2) sash locks.

- c. Access Doors up to 24 by 48 Inches: Three (3) hinges and two (2) compression latches with outside and inside handles.
- d. Access Doors Larger Than 24 by 48 Inches: Four (4) hinges and two (2) compression latches with outside and inside handles.

C. Pressure Relief Access Door:

- 1. Door and Frame Material: Galvanized sheet steel.
- 2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
- 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
- 4. Doors close when pressures are within set-point range.
- 5. Hinge: Continuous piano.
- 6. Latches: Cam.
- 7. Seal: Neoprene or foam rubber.
- 8. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.10 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Flame Gard, Inc.
 - 3. 3M.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 INSULATED FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.

- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3½ inches wide attached to 2 strips of 2¾-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd.
 - 2. Minimum Tensile Strength: 500 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd.
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.
- H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
 - 4. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
 - 5. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of ¼-inch movement at start and stop.

2.12 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Flexmaster U.S.A., Inc.
 - 2. McGill AirFlow LLC.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

- B. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; 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 20 to plus 210 deg F.
 - 4. Installed Insulation value: R-5
- C. Flexible Duct Connectors:
 - 1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.13 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.14 SOUND LAGGING INSULATION

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Sound Seal.
- B. Flexible, 2 lb/square foot reinforced foil-faced mass loaded vinyl noise barrier, 0.23 inch thick.
- C. Foil-faced lag tape.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot spacing.
 - 8. Upstream and downstream from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. Control devices requiring inspection.
 - 11. Elsewhere as indicated.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
- M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

- N. Connect terminal units to supply ducts with maximum 60-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- O. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- P. Connect flexible ducts to metal ducts with liquid adhesive plus tape.
- Q. Install duct test holes where required for testing and balancing purposes.
- R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 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. Centrifugal wall ventilators.
 - 3. Ceiling-mounted ventilators.
 - 4. In-line centrifugal fans.
 - 5. Centrifugal upblast roof ventilators

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, 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.

- C. Delegated-Design Submittal: For unit hangars and supports 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. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

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 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. Belts: One sets 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. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

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 CENTRIFUGAL ROOF VENTILATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Carnes Company.
 - 2. Greenheck Fan Corporation.
 - 3. Loren Cook Company.
- B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector, as required.
 - 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
 - 1. Resiliently mounted to housing.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
 - 3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 - 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 - 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

- F. 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.

2.2 CEILING-MOUNTED VENTILATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. Loren Cook Company.
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: Aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 4. Motion Sensor: Motion detector with adjustable shutoff timer.
 5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
 6. Filter: Washable aluminum to fit between fan and grille.
 7. Isolation: Rubber-in-shear vibration isolators.
 8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 IN-LINE CENTRIFUGAL FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. Loren Cook Company.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 3. Companion Flanges: For inlet and outlet duct connections.
 - 4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.4 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.
- B. Enclosure Type: Totally enclosed, fan cooled.

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.

2.6 CENTRIFUGAL UPBLAST ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corp.
 - 2. Cook, Loren Company
 - 3. Penn Ventilation Companies, Inc.
 - 4. ACME Engineering

- B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
 - 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
 - 1. Resiliently mounted to housing.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted **inside** fan housing, factory wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 - 3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. 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.
 - 1. Configuration: Built-in raised cant and mounting flange.
 - 2. Overall Height: 18 inches.
 - 3. Sound Curb: Curb with sound-absorbing insulation.
 - 4. Metal Liner: Galvanized steel.
 - 5. Vented Curb: Unlined with louvered vents in vertical sides.
- G. Capacities and Characteristics: See Schedule.
- H. UL 762 listed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- 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 suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Install units with clearances for service and maintenance.
- F. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. 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 Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "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.

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ceiling Diffusers
2. Sidewall Registers
3. Spiral Duct Mounted Drum Louver
4. Duct Mounted Diffusers

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. 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.

C. Source quality-control reports.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Handle air terminal units and components carefully to prevent damage.
- B. Store air terminal units and components in clean dry place off the ground. Protect from weather, water and physical damage.

PART 2 - PRODUCTS

2.1 FINISHES

- A. Except where otherwise specified, surface finish will be selected by the Architect. Interior finish shall be flat black.

2.2 ACCESSORIES

- A. Each grille, register and diffuser shall have the accessories required to perform satisfactorily and be fully adjustable. This includes opposed blade volume dampers, air deflectors, vanes, blanking quadrants, etc.
- B. Dampers shall be omitted from the following:
 - 1. Single exhaust grilles, transfer grilles.

2.3 CEILING DIFFUSERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Titus.
 - 2. Price Industries.
 - 3. METALAIRE, Inc.
- B. Material: Aluminum.
- C. Finish: Baked enamel, white.
- D. Face Size: See Schedule.
- E. Mounting: Surface and T-bar. See schedule.
- F. Pattern: Adjustable.
- G. Dampers: Radial opposed blade.

2.4 SIDEWALL REGISTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Titus.
 - 2. Price Industries.
 - 3. METALAIRE, Inc.
- B. Material: Extruded Aluminum.
- C. Finish: Baked enamel, white.
- D. Face Blade Arrangement: Vertical spaced 3/4 inch apart.
- E. Core Construction: Integral.
- F. Rear-Blade Arrangement: Horizontal spaced 3/4 inch apart.
- G. Frame: 1 inch wide.
- H. Mounting: Countersunk screw.

2.5 SPIRAL DUCT MOUNTED DRUM LOUVER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Titus
 - 2. Price Industries.
 - 3. METALAIRE, Inc.
- B. Material: Heavy gauge extruded aluminum.
- C. Finish: Baked enamel.
- D. Drum rotation: minimum 25 degree up and down from centerline of grille. Constructed with radiused end cap and foam gaskets. Louvers shall be directed towards floor at 30 degrees from bottom of duct.
- E. Blades: Heavy duty, individually adjustable.
- F. Universal end cap.
- G. Mounting: Countersunk screw holes and curved border.
- H. Air Scoop Damper/Extractor : Heavy duty aluminum operable from the face with screw driver.

2.6 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.
- B. Provide balancing dampers on duct take-off to diffusers, grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly.
- C. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.

END OF SECTION 233713

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 and chimney.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Special gas vents.
 - 2. Listed building heating appliance chimney.
 - 3. 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 Division 23 Section "Vibration and Seismic Controls for HVAC 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.
 - 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.
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.
- C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.6 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 installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

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: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Metal-Fab, Inc.

2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
 3. Van-Packer Company, Inc.
- 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. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation.
- D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
- E. Outer Jacket: Stainless 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: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.2 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Metal-Fab, Inc.
 2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
 3. Van-Packer Company, Inc.
- B. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F continuously, or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation.
- D. Inner Shell: ASTM A 666, Type 304 stainless steel.
- E. Outer Jacket: Stainless 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 .

2.3 GUYING AND BRACING MATERIALS

- A. Cable: Four galvanized, stranded wires of the following thickness:
1. Minimum Size: 1/4 inch diameter.
 2. For ID Sizes 4 to 15 Inches: 5/16 inch.

PART 3 - 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 Special Gas Vent: Condensing gas appliances.
- B. Listed Heating Building Appliance Chimney: Category I Appliance.

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.
- F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
- G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
- H. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

3.4 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 235216 - 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. This Section includes packaged, factory-fabricated and -assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC 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.
 - 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. Source quality-control test reports.

- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.
- G. 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.
- B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IESNA 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, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
- E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Condensing Boilers:
 - a. Pressure Vessel/Heat Exchanger failure due to condensate corrosion, thermal stress, mechanical defects or workmanship: Nonprorated for seven (5) years from date of Substantial Completion.
 - b. Heat exchanger : twenty (20) years from date of Substantial Completion against thermal shock.
 - c. Burner: five (5) years from date of Substantial Completion.
 - d. All other components : 18-month from date of Substantial Completion against failure due to defective materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Buderus
2. Aerco
3. Viessmann

2.2 CONDENSING BOILERS

A. General:

1. Boilers by alternate manufacturers shall meet the performance requirements as scheduled on the drawings.
2. Boilers shall be gas fired hot water, automatic firing, high efficiency condensing type.
3. Provide insulated jacket, sectional cast iron heat exchanger, wet base design, fuel burning system, refractory, controls and boiler trim.
4. Provide burner mounting plate compatible with burner selected by Contractor.

B. Fabrication:

1. Assemble from cast iron sections with 50 psig ANSI/ASME Boilers and Pressure Vessels Code rating.
2. Provide clean-out and access doors, observation ports and relief openings to flue passages.
3. Provide glass fiber insulated steel jacket, finished with factory applied baked enamel.

C. Hot Water Boiler Trim:

1. Combination water pressure and temperature gage, and ASME rated pressure relief valve with 30 PSIG rating.
2. Low water cut-off with manual reset to automatically prevent burner operation when boiler water falls below safe level. Low water cut-off shall be testable without draining system.
3. Operating temperature controller shall start and stop boiler.
4. Manual reset, high limit temperature controller for burner to prevent boiler water from exceeding safe system temperature.
5. Modulation control.
6. Boiler air vent.

2.3 BURNERS

A. Manufacturers

1. Webster
 2. Viessman
 3. Riello
- B. General
1. Supply, start-up, code/utility compliance and service shall be included in work of burner distributor.
- C. Burner shall be for forced draft combustion of natural gas.
- D. Burner Operation: Full modulation with low fire position for ignition.
- E. Burner shall be of welded steel construction. Design shall include adjustable primary air/gas pre-mix chamber.
- F. Ignition system shall be spark ignited gas pilot with 10,000 volt transformer and to ensure total fuel independence, the main oil flame shall be ignited by direct spark ignition with 12,000 volt transformer.
- G. All air required for combustion shall be provided by blower mounted integral to burner.
- H. Burner FM listed gas train shall include the following:
1. Main gas cock.
 2. Main gas pressure regulator for 5 in wc inlet pressure. (Coordinate pressure requirements with plumbing drawings.)
 3. Low gas pressure safety switch.
 4. Auxiliary gas valve.
 5. Main gas valve.
 6. Manual leak test cock.
 7. High gas pressure safety switch.
- I. Burner and gas train shall meet or exceed the requirements of UL, FM and CSD-1B and owners insurer. Burner gas train shall meet minimum requirements of gas utility.
- J. Burner Control Cabinet.
1. Factory-wired top horizontal mounted to burner.
 2. Provide with prepurge, postpurge, UV detector, single point power supply, motor starters for blower, circuit breaker for blower, control circuit switch, four indicating lights, control circuit transformer and local/remote switch to allow operation independent of boiler room controller.
- K. Refer to schedule on drawings for burner performance.
- L. Building Management System Interface: Factory-installed Lonmark/LonWorks interface to enable building management system to monitor and control hot-water set point, boiler enable and display boiler status and alarms. Coordinate with and provide information for submittals to Division 15970 Controls contractor.

2.3 CONTROLS AND FIRING MODE

- A. Controls shall include an electronic proportional integrated combination limit/operator control accurate to 1 deg. F having a 4-20 mA output signal suitable for control of a variable frequency motor drive. The control shall also provide readouts of boiler target, differential and inlet/outlet temperatures as well as accumulated run time. An on/off switch and full diagnostic light package shall be provided. The complete control package shall be mounted on the front panel with hinged door for easy access to all control modules. A flow switch shall be provided loose.
- B. The burner shall operate as fully modulating down to 35% of the heating load.
- C. Light off shall be at no more than 50% input to assure rumble free soft start.
- D. Each boiler shall incorporate dual over-temperature protection with manual reset and an electric low water cut-off with manual reset, both in accordance with ASME Section IV and CSD-1.

2.5 GAS TRAIN AND IGNITION MODE

- A. The gas train shall consist of a gas valve with pressure regulating electro-hydraulic actuator to provide slow opening, fast closing, safety shutoff and air/gas ratio control. A factory pre-set combination metering valve and orifice shall be provided for setting combustion parameters.
- B. The ignition module shall employ a proved igniter with 3 tries for ignition and with 1 hour reset. Trial for ignition shall be 10 seconds with 15 seconds between retrials.

2.6 BOILER OPERATING CONTROLS

- A. Refer to Section 230900.
- B. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control hot-water set point and display boiler status and alarms.
 - 1. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.7 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section I, for high-pressure boilers and Section IV, for low-pressure boilers.

2.8 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 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 nonfused 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.

2.9 VENTING

- A. Category IV venting: Refer to Section 23 51 00.
- B. Combustion-Air Intake: Complete system, galvanized duct terminating through louver with screen.

2.10 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 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. Before boiler installation, 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 boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations 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. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Vibration Isolation: Elastomeric isolation pads with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results for HVAC,"

E. 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.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

- I. Boiler Venting:
 - 1. Install combustion-air intake.
 - 2. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks." And manufacturer's requirement.
- J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 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. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
 - c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. 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(4) visits to Project during other than normal occupancy hours for this purpose.
- E. 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.
 - b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
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 not adequate.
 7. Notify Architect in advance of test dates.
 8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 235216

1 PART 1 – GENERAL

1.1 SECTION INCLUDES

- A. Design, performance criteria, controls, and installation requirements for Air Handling Units.

1.2 REFERENCES

- A. All components selected for this project shall conform to the following Standards:

1. American Bearing Manufacturer’s Association (ABMA) Publications:

9-1990 Load Ratings and Fatigue Life for Ball Bearings
(R 2008)

2. Air Movement and Control Association (AMCA) Publications:

204-05 Balance Quality and Vibration Levels for Fans
(R 2012)
210-07 Testing Fans for Certified Aerodynamic Performance Rating
300-08 Reverberant Room Method for Sound Testing of Fans
320-08 Sound Testing of Fans Using Sound Intensity
500-L-12 Testing Louvers for Rating

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI) Publications:

410-01 Forced-Circulation Air-Cooling and Air-Heating Coils
1060-11 Air-to-Air Heat Exchangers for Energy Recovery Ventilation
Equipment

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Publications:

84-02 Testing Air-to-Air Heat/Energy Exchangers

5. Institute of Electrical and Electronics Engineers (IEEE) Publications:

112-04 Polyphase Induction Motors and Generators

6. National Electric Manufacturers Association (NEMA) Publications:

MG-1-11 Motors and Generators

7. National Fire Protection Association (NFPA) Publications:

- 70-11 National Electric Code
- 90A-12 Installation of Air-Conditioning and Ventilating Systems

8. Underwriters Laboratories (UL) Publications:

- 181-05 Factory-Made Air Ducts and Air Connectors
- 723-08 Surface Burning Characteristics of Building Materials
- 900-04 Air Filter Units
- 1995-11 Heating and Cooling Equipment

9. American Society for Testing and Materials (ASTM) Publications:

- A 653-11 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- B 43-09 Seamless Red Brass Pipe, Standard Sizes
- B 75-11 Seamless Copper Tube
- B 251-10 General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
- E 84-12 Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Division 1.
- B. Submittals shall include the following:
 - 1. Dimensioned plan and elevation view drawings and location of all field duct connections and openings.
 - 2. Manufacturer's performance of each unit. Performance sheets shall include, as a minimum, the following:
 - a. Input data used for selection.
 - b. Unit model number.
 - c. Energy recovery performances.
 - d. Cooling performances.
 - e. Heating performances.
 - f. Fan curves.
 - g. Unit electrical data (voltage, FLA, MCA, MOP).
 - h. Approximate unit shipping weight.
 - 3. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 320, 500-L and ARHI 410.
 - 4. Unit construction and component summary
 - 5. Unit sequence of operation, including flow schematic, list of contacts and signals and control accessories

1.4 OPERATION AND MAINTENANCE DATA

- A. Include data on design, inspection and procedures related to preventative maintenance. Operation and Maintenance manuals shall be submitted at the time of unit shipment.

1.5 QUALIFICATIONS

- A. Air handling unit manufacturer shall have a minimum of twenty-five (25) years experience in the energy recovery market.
- B. Energy recovery units shall be capable of transferring sensible, latent or total energy as listed in the equipment schedule. Energy transfer device shall be certified to AHRI 1060 and bear the AHRI seal.
- C. Units shall carry the label of a Nationally Recognized Testing Laboratory (NRTL) or a Standards Council of Canada (SCC) approved lab (Testing Organization and Certifying Body).
- D. Units shall be constructed in accordance with CAN/CSA C22.2 No. 236 and UL 1995. Each unit shall bear an ETL or UL label under UL 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.
- E. Units shall be constructed to provide smooth interior surfaces.
- F. Units shall comply with NFPA 70 as applicable for installation and electrical connections of ancillary electrical components of air handling units.
- G. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A.
- H. Units shall deliver the specified volume of air at the scheduled static pressure.
- I. Airflow data shall comply with AMCA 210 method of testing.
- J. All electrical components and assemblies shall comply with NEMA standards.
- K. If manufacturer cannot provide any of the items or options listed within this specification it must be noted as an exception on the bid.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site under the supervision of the Owner and per manufacturer's recommendations. Refer to manufacturer's installation, operation and maintenance (IOM) manual for proper installation

procedures. Manufacturer is not responsible for any damage done to the units caused by poor rigging or installation operation.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate work performed under this section with work performed under the separate installation contract.

1.8 WARRANTY

- A. The complete units shall be covered by a parts warranty issued by the manufacturer, warranting the units to be free from defects in material and workmanship for twelve (12) months from date of shipment unless a start-up form is on file and accepted by Venmar CES, in which case the warranty is twelve (12) months from the date of startup, or eighteen (18) months from date of shipment, whichever is shorter.
- B. The installing contractor shall provide labor warranty during the units' first year of operation.

2 PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design:
 - 1. Venmar CES, Inc.; Model EnergyPack[®] air handling units
- B. Acceptable Manufacturers:
 - 1. Innovent
 - 2. Annexaire

2.2 GENERAL

- A. Furnish and install where shown on the plans, air handling units with design features as specified within this specification. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The Contractor shall be responsible for any additional expenses that may occur due to any exception made.
- B. The units shall be installed and oriented such that the outside fresh air intake hood is positioned in a direction opposite to prevailing winds.

2.3 FACTORY TESTING AND QUALITY CONTROL

- A. Standard Factory Tests: Units shall be factory run tested to ensure proper functioning of components. Fans shall be factory run tested to ensure structural integrity and proper RPM, and shall be statically and dynamically balanced for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 204. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

2.4 UNIT CONSTRUCTION DESCRIPTION

- A. General – Provide factory-fabricated air handling units with capacity as indicated on the schedule. The units consist of factory-assembled components as shown on drawings, including but not limited to fan and motor assemblies, energy recovery device, all necessary dampers, hoods (outdoor units only), plenums, filters, drain pans, wiring, controls and other accessories as outlined in the schedule, enclosed in a single or multiple-piece casing as shown on the mechanical drawings. Units shall be integrated into existing building management system, with all control devices provided and wired for single point power connection by the manufacturer unless otherwise outlined in the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams and installation, operation and maintenance (IOM) manuals shall be attached to the control panel access doors within each unit. Units shall be UL or ETL listed. Units shall be shipped in one (1) piece or shall be split for shipment to accommodate freight as required, as shown on mechanical drawings.
- B. Unit Base and Floor – Unit perimeter base shall be completely welded and constructed from 6 inch structural tubing, and shall accommodate curb or concrete pad installation as shown on Drawings (Note: Bolted or riveted bases are not acceptable). Unit base shall be internally insulated with 4 inch, R13.3 fiberglass. Unit base floor shall be constructed from four (4) break formed steel panels, made from 14 gauge hot rolled steel (HRS). Floor panels shall be welded to each other, creating “I” beams at each floor panel junction. Floor panel junctions shall be located at 14 inch increments (maximum) or less, in order to provide floor rigidity and support as required for internal components. Unit floor panels shall be welded to perimeter base frame steel tubing. Unit floor shall be factory covered with top coat industrial grade membrane to ensure air and water tightness as well as walk-on grip. Floor membrane shall be high performance, sprayed, plural-component pure polyurea elastomer, based on amine-terminated polyether resins, amine chain extenders and prepolymers. Floor membrane shall be flexible, tough, resilient monolithic membrane with good water and chemical resistance, and shall resist to temperatures up to 250°F. Floor membrane materials shall be free of solvents and

VOC's, shall be suitable for use in compartments handling conditioned air, and shall comply with the requirements of ANSI/UL 1995, Section 5.10 and Section 18. Unit base under liners shall be made of 24 gauge galvanized steel. Base frame construction shall include 2-stage thermal break, using gasket between base floor framing and under liners underneath, and floor membrane on top. Single wall floor construction with glued and pinned insulation and no sub-floor is not acceptable; non-insulated floor construction is not acceptable. Floor constructions which are not air and water tight are not acceptable. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Base frame shall be attached to the unit at the factory. When rigging, base frame deflection shall be less than 1/360 of the unit length. All major components shall be supported by the base without sagging or pulsating.

- C. Rigging Provision – Single Piece Units: The unit base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed using all lifting lugs at all time, and in strict accordance with the instructions provided within the installation, operation and maintenance (IOM) manual. Lifting lugs may be removed after rigging; however bolts shall be set back in place after lug removal.
- D. Rigging Provision – Multiple Piece Units: Units shipped in multiple sections shall be engineered for field assembly. The unit section base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed using all lifting lugs at all time, and in strict accordance with the instructions provided within the installation, operation and maintenance (IOM) manual. Peripheral lifting lugs may be removed after rigging; however bolts shall be set back in place after lug removal. Lifting lugs located along a section side corresponding to a unit section split shall be removed without bolts being set back in place afterwards. Units shall be provided with all necessary gaskets, caulking, hardware and instruction for assembly on site by installing contractor. Compression points shall be provided at the base frame, along the sides at 18 inch increments and at the top for aligning and joining section splits.
- E. Unit Casing – Unit wall and roof rigid frame shall consist of 16 ga. pre-painted galvanized formed steel corner posts and 16 ga. G90 galvanized formed steel 1 inch x 2 inch intermediate frame posts, providing stable construction allowing for removal of any panel without affecting unit structural integrity. Units without framed type of construction are not acceptable. Exterior casing panels shall be attached to the gasketed 1 inch x 2 inch steel frame with corrosion resistant fasteners. Air handling unit casing shall be of the “no-through-metal” design. Casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there is no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection,

additional internal reinforcing is required. Units shall be designed for outdoor or indoor installation as indicated on schedule. Indoor units weatherized for outdoor use are not acceptable. Outdoor units shall have a double-sloped roof with three percent (3%) minimum roof pitch to prevent water accumulation, rain gutters above all access doors and roof joint seams of the "T" shape construction, with minimum height of 1 inch, metal strip sealed and encapsulated. Outdoor units shall be designed to resist snow, ice and wind loads, and provided with weather hood(s) equipped with bird screen and rain gutters. All panel seams shall be caulked and sealed for an airtight unit. Leakage rates shall be less than one percent (1%) at design static pressure or 9 inch W.C. whichever is greater. Outdoor unit outside skin shall be made of pre-painted steel unless otherwise specified. Indoor units shall be provided with unpainted G90 galvanized steel unless otherwise specified. All galvanized steel surfaces requiring paint shall be made of satincoat-finished galvanized steel of the specified gauge(s). All galvanized steel surfaces without any paint shall be made of galvanized steel of the specified gauge(s).

- F. Double Wall Construction – Units shall entirely be made of double wall construction. Single wall construction with coated insulation is not acceptable. Exposed insulation edges in the air stream are not acceptable. Unit panels shall be made of 18 ga. galvanized steel outer liners and 24 ga. galvanized steel inner liners.
- G. Insulation – Unit wall and roof panels shall be insulated with 3 inch thick, R12.9, 2.5 lb/cu. ft. non-compressed mineral wool insulation. Unit internal partition (dual air tunnel units) shall be insulated with 2 inch thick, R8.6, 2.5 lb/cu. ft. non-compressed mineral wool insulation. Insulation shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E 84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the panels. All perforated sections shall have insulation with black acrylic coating.
- H. Access Doors – Full size access doors allowing for periodic maintenance and inspections shall be provided for all serviceable components as shown on the plans. Removable panels are not acceptable. Doors shall be solid double wall insulated construction. Insulation shall be the same as unit panels. Both the inner and outer liners shall be made of the same material as unit cabinet outer liner construction. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. Hinges shall allow doors to open at 180° with no shear effect on the hinge side of the perimeter gasket. The doorframe shall be extruded aluminum with a built in thermal break barrier and full perimeter gasket. The door gasketing shall employ a double seal comprising of an adhesive neoprene compressible foam gasket on the outer door panel and an "automotive style" neoprene bulb gasket fixed onto the inner door frame for out-swing doors, "rippled" foam for in-swing doors. There shall be a minimum of two (2) heavy duty cast, UV rated, nylon handles per door. Door handles shall be

operable from both inside and outside of the unit. On all access doors where moving parts could cause injury, an ETL, UL 1995 and OSHA approved tool operated safety latch shall be provided.

Note: If manufacturer cannot provide thermal break door design it must be noted as an exception on the bid.

- I. Condensate/Drain Pans – Drain pans shall be provided as shown on the drawings. The drain pan shall be fabricated from 16 gauge stainless steel. All drain connections shall be piped and trapped (in field, by others) separately for proper drainage. Drain pans shall be sloped at a minimum of one and one half percent (1.5%) with a drain pipe sweat connection of 1¼ inches ending through the structural base frame. All drain pan corners shall be welded.

2.5 UNIT COMPONENT DESCRIPTION

- A. Enthalpy Wheel Heat Exchanger – Energy transfer ratings shall be AHRI 1060 certified and bear the AHRI certification seal for AHRI Air-to-Air Energy Recovery Ventilation Equipment Program. Ratings in accordance with AHRI 1060 without certification are not acceptable. Heat Exchanger shall be tested in accordance with ASHRAE 84. An access section shall be provided both upstream and downstream of the wheel to allow for servicing. Wheel media shall be made of 2 mil minimum corrugated aluminum. All surfaces shall be permanently bonded with a non-migrating desiccant specifically developed for water vapor transfer. Etched or oxidized surfaces are not acceptable. Wheel shall transfer energy between airstreams in a counter flow configuration. Wheel cleaning shall be with low-pressure air or vacuum cleaner. Dry particles up to 1,200 microns shall freely pass through the wide angle media minimizing air pressure drop. Rotor casing shall be provided with a structural framework that limits rotor deflection due to air pressure differential to less than 1/32 inch. Wheel shall be equipped with labyrinth beam seals, brush partition seals, and contact perimeter seals for wheel diameters from 54 to 120 inches and with brush seals for diameters less than 54 inches. Wheel shall be segmented to allow removal in pieces for diameters from 54 to 120 inches.
- B. Unit Fans (SWSI and DWDI) – Fan assemblies shall be designed for heavy-duty industrial applications. All fans shall meet the air flow performance specified and shall not exceed the break horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA 210 for performance and AMCA 300 for sound. Fans shall be selected for stable operation, at least twenty percent (20%) under the first critical speed of the fan, with a steep pressure/volume curve. Fan shaft shall be turned, ground and polished solid steel, finished off with a corrosion resistant coating and rated at maximum RPM below critical speed. Fan wheel and sheaves shall be keyed to the shaft. Fan drives shall be designed for a 1.3 service factor. Pulleys shall be factory-mounted with final alignment and belt adjustment completed before unit start-up. Motor (driver) and fan (driven) pulleys shall be of

fixed pitch. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type, selected for a minimum average bearing life (L-50) in excess of two hundred thousand (200,000) hours at maximum operating speed in accordance with ABMA 9 Standards. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades. Fan and motor assemblies shall be mounted inside the unit casing, on a base equipped with 1 inch deflection spring vibration isolators and supplied with flexible connections. Fans shall be balanced per ANSI/AMCA 204 fan application category BV-3 using a digital signal analyzer at the design RPM with belts and drives in place to a vibration velocity less than or equal to 0.157 inches per second measured horizontal and vertical at each bearing pad. Vibration amplitudes are in inches/second-Peak. All values are filter-in at the fan speed. Removable shipping restraints shall be provided to protect the fan, motor and base during shipment.

1. Exhaust Fan: Forward Curved (FC) DWDI housed fans – Fan housing shall be heavy gauge galvanized steel construction. Fan scroll shall be bolted to assembly frame. Fan bearings shall be heavy duty, pillow block, self-aligning ball type. Fan wheel and sheaves shall be keyed to the shaft.
2. Supply Fan: Airfoil Fan (AF) DWDI housed fans – Fan housing shall be heavy gauge galvanized steel construction. Fans shall be double width double inlet as indicated on the schedule. Fan blades shall be hollow airfoil in shape, welded to the center and wheel side plates. Fan bearings shall be heavy duty type. Rigid supports for both bearings must be removable for access to the wheel. Fan housing shall be heavy gauge, continuously welded, steel construction. Inlet cones shall be precision spun and aerodynamically matched.
3. Motors shall be heavy duty, constructed to NEMA MG 1, general purpose, continuous duty, Design B. Temperature rating shall be 122°F maximum temperature rise at 104°F ambient for continuous duty at full load (Class B Insulation). Motors shall be T-FRAME mounted on an adjustable steel base that allows for belt alignment and tensioning, within the unit casing. All motors shall be tested to IEEE 112 test method B and rated per NEMA MG1, Part 31 “Inverter Fed Motors”. Motor bearings shall be ball or roller type with inner and outer shaft seals, grease lubricated and designed to resist thrust loading where belt or other drives produce lateral or axial thrust in motors. All motors shall be specifically designed to meet or exceed all EPAAct requirements for energy efficiency and include Class ‘F’ insulation. Motor shall be of minimum size as indicated in the equipment schedule, 1800 rpm, open drip proof (ODP), and have a 1.15 service factor. Motor torque shall efficiently accelerate the drive loads. Unless indicated, motor shall not operate in the service factor range.
4. VFDs – Each variable air volume supply and return fan shall be provided with separate variable frequency drives. Drives shall be factory mounted with adequate ventilation provided. The variable frequency drive shall convert input voltage (with plus or minus ten percent (+/- 10%) tolerance),

three phase, 60 hertz (+/- 2 Hz.) utility power to adjustable voltage/frequency, three phase, A-C power step less motor control from five to one hundred five percent (5-105%) of base speed. The variable frequency drive (VFD) shall produce an adjustable A-C voltage/frequency output of complete motor speed control and an input power factor near unity over the entire speed range. The VFD shall be automatically controlled by a control signal. The VFD shall be self contained, totally enclosed in a NEMA 1 ventilated cabinet and capable of operation between 0 and 40° Celsius. The VFD shall be UL listed. Components used in all options shall be UL listed. The VFD shall have a hand/off/auto operator switch, drive switch with run or stop command and panel mounted digital display capable of indicating unit status, frequency, and fault diagnostics.

- C. Coils – General Information (applicable to Hydronic, Direct Expansion Coils) – Acceptable coils shall have AHRI 410 certification and bear the AHRI symbol. Coils shall be submerged in water and tested to a minimum dry air/nitrogen pressure of 300 psig standard copper tube coils. Coils shall display a tag with the inspector's identification as proof of testing. Tubes shall have a nominal thickness of 0.020 inches unless otherwise specified. Fins shall be made of 0.0075 inch thick aluminum unless otherwise specified. Tubing, return bends and headers shall be made of seamless UNS 12200 copper meeting ASTM B 75 and B 251. Coil return headers shall be equipped with factory-installed 1.2 inch FPT air vent connections placed at the highest point available on the face of the header (except for evaporator coils). Casings and endplates shall be made of 16 gauge galvanized steel, meeting ASTM A 653 unless otherwise noted. Double flanged casings on the top and bottom of finned height shall be provided to allow for coil stacking. Piping, control valve and valve operator shall be supplied and installed by others.
- D. Hydronic Coils – Hydronic coils shall be designed to withstand 250 psig maximum operating pressure and a maximum water temperature of 300°F for standard duty copper tube coils. Standard construction fluid MPT connections shall be made from red brass meeting ASTM B 43 or Schedule-40 steel pipe as a minimum. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout. Fins shall be made of 0.0075 inch thick aluminum and mechanically bonded to copper tubes.
- E. Direct Expansion Coils – Coils shall be tested to be leak-free with nitrogen or dry (at least 300 psig) air underwater. Standard construction connections shall be sweat-soldered and constructed of copper. Distributor shall be designed to have a removable nozzle to allow for installing an auxiliary side connection for hot gas bypass. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout. Fins shall be made of 0.0075 inch thick aluminum and mechanically bonded to copper tubes.

- F. Hot Gas Reheat Coils – Coils shall be tested to be leak-free with nitrogen at 500 psig underwater in an illuminated tank. After testing, coils shall be emptied, thoroughly dried and capped. Coil tube size and wall thickness shall be 5/8 inch x 0.020 inch. Tubes shall be rifled. Fins shall be made of 0.0075 inch thick aluminum and mechanically bonded to copper tubes. Standard construction fluid connections shall be sweat-soldered and made of copper. Coil shall be multi-circuited as required.
- G. Refrigerant Circuits – General Information – Entire unit, including all refrigeration circuits, shall be manufactured as one (1) single system, at the same time and location, by the unit manufacturer. Systems where the unit manufacturer is purchasing a condensing unit from another manufacturer, and integrating it to the unit, are not acceptable. Refrigeration section shall be designed for full and easy access for maintenance. Entire refrigerant piping circuit shall be leak-tested at 150 psig air pressure. Capacity modulation shall be provided by hot gas bypass on lead compressor.

Refrigerant circuit components shall include: thermal expansion valve, distributor, liquid line filter drier, charging valve and high and low pressure side gauge ports. Refrigerant circuits may also include:

OPTIONS: - Modulating hot gas reheat valves.

All refrigerant piping shall be of K, L or ACR copper type. The complete system shall be factory-dehydrated and pressure-tested at 300 psi; the system shall then be factory charged with refrigerant (except for units shipped in multiple sections where refrigeration circuit is split in multiple sections, in such case the units shall be shipped with nitrogen holding charge):

OPTIONS: - R-410A

Suction and hot gas bypass lines shall be insulated with 3/8 inch thick elastomeric pipe insulation. Pipe insulation exposed to UV Light radiation shall be protected with aluminum tape. Safety controls shall include a high and low refrigerant pressure switch on each circuit for protection against loss of charge. Each refrigerant circuit shall include DDC-controlled compressor anti-cycling. Each refrigerant line present in other compartments than only the compressor compartment shall be clearly identified with the use of labels showing both the refrigerant line's duty (suction, liquid, discharge, hot gas bypass, hot gas reheat) along with the circuit number (i.e. suction 1, liquid 3, etc). This labelling shall be repeated in each compartment of the unit (else than the compressor compartment) where refrigerant lines are present, such way that all refrigerant lines in any other compartment can easily be identified. Unit water inlet and water outlet lines shall be clearly identified with the use of labels showing "Water inlet" and "Water outlet" near the point of connection to the building's water network.

- H. Integrated Air-Cooled Condensing Section – Each refrigerant circuit shall include

moisture indicating sight glass, filter/drier, liquid line isolation valve, compressor isolation valves and externally equalized thermostatic expansion valve. Safety controls shall be auto reset on low pressure side and manual reset on high pressure side. The complete refrigerant piping shall be factory-tested on factory-charged units.

Condenser coils shall be tested to be leak-free with nitrogen at 500 psig underwater in an illuminated tank. After testing, coils shall be evacuated, thoroughly dried and capped. Coil tube size and wall thickness shall be 3/8 inch x 0.020 inch standard copper. Tubes shall be rifled. Fins shall be made of 0.0075 inch thick aluminum on R-410A systems and of 0.0060 inch on R-407c systems and mechanically bonded to copper tubes. A 15°F sub-cooling section shall be an integral part of the condenser coil. Standard construction fluid connections are sweat-soldered and made of copper.

- I. Scroll Compressors – Compressor shall be hermetically sealed scroll type with a forced-feed lubrication system and oil charge. Compressor motor shall be suction-cooled motor windings with inherent internal line break protection and mounted on RIS vibration isolators. Compressor shall include internal pressure relief valve, gas sensor and device to limit the shut-down noise caused by scroll reversal. Each compressor shall have a crankcase heater that is independently fused and will remain energized at all times unless unit is disconnected at the main power source.
- J. Filters –Factory fabricated filter sections shall be of the same construction and finish as the unit. Outside and return air inlets shall be equipped with galvanized steel racks that permit filter slide out removal (side access) for units equal or less than 78 inches tall and universal holding frames with upstream access (face loading) for units taller than 78 inches. Face loaded pre and final filters shall have Type 8 frames as manufactured by AAF, FARR or equal. Side service filter sections shall include hinged access doors. Internal blank-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters. The filters shall be as manufactured by Farr, Purolator, AAF or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters. Filter air velocity shall not exceed 500 fpm through each filter bank. Units shall be equipped, to a minimum, with 2 inch thick, thirty percent (30%) efficient (MERV 7) medium efficiency pleated filters.
- K. Flat Racks – Filter racks shall be completely factory assembled and designed for industrial applications. Filter racks shall be fabricated from no less than 16 gauge galvanized steel. Filter racks shall be applied in low efficiency filter applications and will be either upstream or side accessible. Side accessible filter racks shall have an oversized access door on the exterior of the air handler, centered on the filter rack for easy filter removal. Upstream access filter racks shall have one central access cover per row of filters centered in the unit for easy access. Filter racks over 72 inches in length shall require an angle center reinforcement support.

Filter racks shall be designed for a maximum of 500 fpm, or meet or exceed the area specified in the equipment schedule.

- L. Dampers – Unit shall be equipped with all necessary dampers required for the system as shown on the mechanical drawings. Dampers shall be designed for operating temperatures between -40°F and 212°F. Air leakage through a 48 inch x 48 inch damper shall not exceed 10.3 cfm/sq. ft. against 4 in. w.g. differential static pressure at standard air condition. Standard air leakage data to be rated in accordance with AMCA certified rating program. Outside air dampers shall be opposed blade motorized and exhaust air dampers shall be of parallel blade gravity backdraft type. For other dampers, see manufacturer's recommendations. Damper actuators drive voltage shall be with 24 VAC for two (2) position or 0-10 volt for modulation. Flat or formed metal blades are not acceptable.

Damper construction shall be as follows: damper frame shall be of extruded aluminum or galvanized steel; damper blades shall be of extruded aluminum; dampers shall be of opposed blade type; damper blade ends shall be sealed with neoprene edge seals with bottom and top blade wiper seals.

- M. Rain Hoods – Rain hoods shall be fabricated from same material as unit casing with ¼ inch wire mesh inlet screen. Hoods sized to minimize moisture carry over.

2.6 ELECTRICAL POWER AND CONTROLS

- A. All wiring and electrical connections shall be of copper wires, copper bus bars, and copper fittings throughout, except internal wire of the control transformer may be aluminum, if copper termination is provided. Power supply terminals shall be identified with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating.
- B. All high voltage wiring conduit shall consist of flexible metal conduit. All low voltage and signal wiring shall consist of Belden cable.
- C. When unit section splits are present, low voltage wiring shall be split using quick connectors for quick and easy field installation. Additionally, for each set of quick connector, the male branch in one unit section and the corresponding female branch in the next unit section shall be identified with the use of a colour code or numbered labels. At each high voltage line split, a junction box shall be provided in one of the sections; the wiring in the section where the junction box is located and the matching wiring in the next section shall be identified with the use of a colour code or numbered labels.
- D. The unit shall feature a mounted permanent nameplate displaying at a minimum the manufacturer, serial number, model number, date of manufacture, and current

and voltage readings. The unit must have an ETL or UL Listing and bear the appropriate mark.

- E. A recessed integral electrical control compartment shall be furnished on the side of the unit. The compartment shall be constructed to NEMA 3R requirements, provided with a hinged access door and a locking device. All components, except those not mounted directly in the unit, shall be factory-mounted and wired to a labelled terminal strip. All components and wiring shall be identified using printed self-adhesive labels, consistent with the numbering used in the wiring diagrams. Control components shall include, but not limited to, single point connection power distribution block, sub and control circuit fuses or circuit breakers, control transformers, motor starters and overloads for single speed operation. The control system shall be factory mounted in the control compartment and shall be a stand-alone microprocessor-based DDC from Johnson Controls with necessary sensors and interfaces to monitor and operate all functions as outlined in the equipment/control schedule, flow schematic, sequence or required for complete unit operation. A unit-mounted intelligent programmable interface device shall be included for communication, display and set-point control and a Hand/Off/Auto switch to allow for servicing. Control panel compartment heaters and thermostats or cooling fans with grills or registers shall be provided if control panels components cannot be protected from their minimum or maximum ambient temperature ratings. For automatic unit start-up an external dry contact must be provided by others. The DDC control system shall be factory-programmed and factory run-tested prior to shipment to verify functions and logic.
- F. A flow schematic with sensor and component identification and location, interlocks, sequence of operation and factory set-points shall be included with submittals.
- G. A wiring schematic and a bill of materials shall be completed in ladder/logic format, with component labelling according to line numbers, once a release for production has been received. The wiring schematic, bill of materials and flow schematic shall be submitted prior to unit shipment and included within the units control compartment.
- H. Frost Control Strategies – Unit shall be provided with Variable speed frost control strategy, which consists of a DDC controlled VFD complete with an A/C inverter duty wheel motor and appropriate controls per sequence of operation. This frost control strategy allows the process of energy recovery to occur while the unit is in frost control mode (available for enthalpy wheel only).
- I. The units shall be provided with the following features:
 - 1. Circuit breaker mounted within the control enclosure with a door interlocked handle on the exterior.

2. Unit shall be supplied with a NEMA 3R weatherproof, non fused, single point main power disconnect switch shipped loose for field installation by the installing contractor.
3. Terminal board shall be provided for 24V low voltage control wiring.
4. The DDC controller shall be programmed to allow the BMS to start/stop the unit, for monitoring, reset and/or alarm functions as indicated in the control schedule.
5. The control system with necessary sensors and interfaces shall be field-supplied, programmed, mounted, wired and run-tested by the control contractor. The control contractor shall co-ordinate sensors, interfaces, mounting locations and logic with the unit manufacturer. The control system shall be (separately mounted/mounted in the control compartment).

3 PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 238126 – SPLIT SYSTEM AIR CONDITIONER

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 split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- 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.
- C. Field quality-control reports.
- D. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
- E. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-Up."

- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Units: one (1) year from date of substantial completion.
 - b. For Compressor Five (5) years from date of Substantial Completion.

1.7 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. Filters: One (1) set for each air-handling unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Daikin AC
 2. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
 3. Enviromaster International
 4. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.

2.2 INDOOR UNITS 5 TONS OR LESS

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:
 - a. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - b. Enclosure Type: Totally enclosed, fan cooled.
 - c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
 - d. Mount unit-mounted disconnect switches on interior of unit.
5. Condensate Drain Pans:
 - a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face
 - 2) Depth: A minimum of 1 inch deep.
 - b. Single-wall, galvanized-steel sheet.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: NPS 1
6. Air Filtration Section:
 - a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
 - 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
 - b. Disposable Panel Filters:
 - 1) Factory-fabricated, viscous-coated, flat-panel type.
 - 2) Thickness: 1 inch.
 - 3) MERV 6

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant Charge: R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 0 deg F.
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- C. Thermostat: Wired to control compressor and evaporator fan, with the following features:
 1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- D. Automatic-reset timer to prevent rapid cycling of compressor.
- E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- F. Condensate drain pump: Field Installed. Mount in the unit.

2.5 CAPACITIES AND CHARACTERISTICS

- A. Cooling Capacity: See Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Install seismic restraints.
- E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. See Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

- D. Prepare test and inspection reports.

3.4 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.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238126

SECTION 238216.11 - HYDRONIC AIR COILS

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 hydronic heating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

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

1. Aerofin.
 2. Dunham-Bush USA.
 3. USA Coil & Air.
- B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.
- D. Source Quality Control: Factory tested to 300 psig.
- E. Tubes: ASTM B 743 copper, minimum 0.049 inch thick.
- F. Fins: Aluminum, minimum 0.010 inch thick.
- G. Headers: Seamless copper tube with brazed joints, prime coated.
- H. Frames: Galvanized-steel channel frame, minimum 0.079 inch thick for slip-in or flanged mounting.
- I. Frames: ASTM A 666, Type 304 stainless steel, minimum 0.0625 inch thick for slip-in or flanged mounting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install galvanized-steel drain pan under each cooling coil.
 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 3. Extend drain pan upstream and downstream from coil face.

- 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230900 "Instrumentation and Control for HVAC," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 238216.11

SECTION 238233 - CONVECTORS

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 convectors.

1.3 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 units with factory-applied color finishes.
- E. Color Samples for Verification: For each type of exposed finish.

1.4 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 convectors will be attached.
 - 2. Method of attaching convectors to building structure.

3. Penetrations of fire-rated wall and floor assemblies.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER CONVECTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Engineered Air.
 2. Rosemex.
 3. Slant/Fin Corporation.
 4. Sterling Hydronics; a Mestek company.
- B. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig.
- C. Front and Top Panel: Minimum 0.0677-inch- thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
- D. Wall-Mounted Back and End Panels: Minimum 0.0428-inch- thick steel.
- E. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel.
- F. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- G. Insulation: 1/2-inch- thick, fibrous glass on inside of the back of the enclosure.
- H. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
- I. Damper: Knob-operated internal damper.
- J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- K. Enclosure Style: Sloped top.
1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a. Mill-finish aluminum.
 - b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
 - c. Painted to match enclosure.
 2. Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a. Mill-finish aluminum.

- b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
- c. Painted to match enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive convectors 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 convector.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install convectors level and plumb.
- B. Install valves within reach of access door provided in enclosure.
- C. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- D. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water convectors and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install piping adjacent to convectors to allow service and maintenance.
- D. Ground electric convectors 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. 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 convectors to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Convectors will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 238233

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 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.

1.4 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. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Embassy Industries, Inc.
 2. Engineered Air.
 3. Hydro-Air Components Inc.
 4. Quincy Hydronic Technology Inc.
 5. Rosemex.
 6. Slant/Fin Corporation.
 7. Sterling Hydronics; a Mestek company.
 8. Trane Inc.
- 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."
- C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.
- D. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends shall be threaded.
- E. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
- F. Front Panel: Minimum 0.0528-inch- thick steel.
- G. Rust-Resistant Front Panel: Minimum 0.064-inch- thick, ASTM A 653/A 653M, G60 galvanized steel.
- H. Wall-Mounted Back Panel: Minimum 0.0329-inch- thick steel, full height, with full-length channel support for front panel without exposed fasteners.
- I. 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.
- J. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- K. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

- L. Damper: Knob-operated internal damper at enclosure outlet.
- M. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches integral with enclosure.
- N. Enclosure Style: Sloped top.
 - 1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a. Painted to match enclosure.
 - 2. Front] Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
 - a. Painted to match enclosure.
- O. 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. Install units level and plumb.
- B. Install enclosure continuously around corners, using outside and inside corner fittings.
- C. Join sections with splice plates and filler pieces to provide continuous enclosure.
- D. Install access doors for access to valves.
- E. Install enclosure continuously from wall to wall.
- F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- G. Install valves within reach of access door provided in enclosure.
- H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- I. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 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 Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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.
- 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 - 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:
 - 1. Cabinet unit heaters with centrifugal fans and hot-water heating coils.
 - 2. Propeller unit heaters with hot-water heating coils.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. CWP: Cold working pressure.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Plans, elevations, sections, and details.
 - 2. Location and size of each field connection.
 - 3. Details of anchorages and attachments to structure and to supported equipment.
 - 4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
 - 5. Location and arrangement of piping valves and specialties.
 - 6. Location and arrangement of integral controls.
 - 7. Wiring Diagrams: Power, signal, and control wiring.

- C. 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. Structural members to which unit heaters will be attached.
 - 2. Method of attaching hangers to building structure.
 - 3. Perimeter moldings for exposed or partially exposed cabinets.
- D. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC 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.
 - 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.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For cabinet unit heaters 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

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. Cabinet Unit Heater Filters: Furnish one spare filter for each filter installed.

PART 2 - PRODUCTS**2.1 HYDRONIC CABINET UNIT HEATERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Airedale
 2. Rittling.
 3. McQuay International.
- B. Description: A factory-assembled and -tested unit complying with ARI 440.
- C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.
1. Thickness: 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.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- D. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
1. Thickness: 1/2 inch.
 2. Thermal Conductivity (k-Value): 0.24 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 C 411.
 4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- E. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
1. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
 2. Control Access Door: Key operated.
- F. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated: 90 percent arrestance and 7 MERV.
- G. 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.

-
- H. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, high static, 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 Section "Common Motor Requirements for HVAC Equipment."
 - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
 - I. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
 - J. BAS Interface Requirements:
 - 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at central workstation.
 - 3. Interface shall be 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.
 - K. Electrical Connection: Factory wire motors and controls for a single field connection.
 - L. Capacities and Characteristics: Refer to Schedule.

2.2 HYDRONIC PROPELLER UNIT HEATERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Airedale
 - 2. Rittling
 - 3. Trane .
- C. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.
- D. Comply with UL 2021.
- E. Comply with UL 823.
- F. Cabinet: Removable panels for maintenance access to controls.

- G. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
- H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- I. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.
- J. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.
- K. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, 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 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.
- L. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- M. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Type: Permanently lubricated, multispeed.
- N. Control Devices:
 - 1. Wall-mounting sensor. Refer to Section 239000.
- O. Capacities and Characteristics
 - 1. Heating Capacity: Refer to Schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- 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 Division 07 Section "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.

- C. Install propeller unit heaters level and plumb.
- D. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- F. Install wall-mounting 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.
- G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. 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 Section "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 unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."
- G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- H. 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

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. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238239

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 019113 “General Commissioning Requirements” for commissioning requirements related to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

COMMON WORK RESULTS FOR ELECTRICAL

- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.6 WARRANTY

- A. Subcontractors shall provide a One (1) Year Labor & Material Warranty that all materials and equipment furnished shall be new and of good quality, free from faults and defects and in conformance with the Contract Documents. Any defects due to faulty workmanship or materials which appear during the first year shall be corrected by the subcontractor at no additional cost to the Construction Manager or Town of Berlin. The Warranty will be the responsibility of the subcontractor for a period of one (1) year from the date of Substantial Completion for that particular building area as the construction phases are completed.
- B. For all major pieces of equipment, the Warranty will commence after the equipment has been put into permanent operating mode, equipment and components have been commissioned and accepted by the Commissioning Agent, and the Operating & Maintenance Manuals have been submitted and approved.
- C. The subcontractor shall, through a Bid Alternate, provide the cost of providing routine maintenance services as documented by manufacturer's operating and maintenance literature. Subcontractor shall be responsible for the manufacturer's recommended maintenance procedures for a period of one (1) year from the time the Warranty commences or until completion of the entire construction project, whichever is later.
- D. Submit written warranties covering work specified in Division 26.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

- b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following into the Work include, but are not limited to, the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 3. Sealing Elements: EPDM and/or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 4. Pressure Plates: Plastic, Carbon steel, Stainless steel. Include two for each sealing element.
 - 5. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

3.2 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/2-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.6 COMISSIONING OF EQUIPMENT

- A. Engage a factory authorized service representative, who is familiar with this project, to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

END OF SECTION 260500

1 PART 1 – GENERAL

1.1 SUMMARY

- A. Demolition involving electrical system as described in Contract Documents

1.2 RELATED SECTIONS

- A. Section 260500 – General Electrical Requirements
- B. New and replacement work specified in appropriate specification Section

1.3 SCHEDULING

- A. Include on Construction Schedule sequence of individual electrical demolition operations.
- B. Coordinate with Owner for equipment and materials to be removed by Owner.

2 PART 2 – PRODUCTS (Not Applicable)

3 PART 3 – EXECUTION

3.1 EXAMINATION

- A. All relocations, reconnections, and removals are not necessarily indicated on Drawings. All such work shall be included without additional cost to Owner.

3.2 PREPARATION

- A. Disconnect equipment that is to be removed or relocated. Carefully remove, disassemble or dismantle as required, and store in approved location on site, existing items to be reused in completed work.
- B. Where affected by demolition or new construction, relocate, extend or repair raceways, conductors, outlets and apparatus to allow continued use of electrical system. Use methods and materials as specified for new construction.

3.3 PERFORMANCE

- A. Perform drilling, cutting, block-offs and demolition work required for removal of necessary portions of electrical system. Do not cut joists, beams, girders, trusses or columns without prior written permission from Architect.
- B. Remove concealed wiring abandoned due to demolition or new construction. Remove circuits, conduits and conductors that are not to be re-used back to next active fixture, device or junction box.

- C. Patch, repair and finish surfaces affected by electrical demolition work, unless work is specifically called for under other Sections of the specifications.

3.4 CLEANING

- A. Remove obsolete raceways, conductors, apparatus and lighting fixtures promptly from site and dispose of legally.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.
- B. Related Sections include the following:
 - 1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
 - 2. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. Alcan Products Corporation; Alcan Cable Division.
 2. American Insulated Wire Corp.; a Leviton Company.
 3. General Cable Corporation.
 4. Senator Wire & Cable Company.
 5. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.
- D. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC, metal-clad cable, Type MC, mineral-insulated, and metal-sheathed cable, Type MI with ground wire.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. AFC Cable Systems, Inc.
 2. Hubbell Power Systems, Inc.
 3. O-Z/Gedney; EGS Electrical Group LLC.
 4. 3M; Electrical Products Division.
 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

- A. Steel Pipe Sleeves: ASTM A 53, 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Plastic, Carbon steel, Stainless steel. Include two (2) for each sealing element.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper for all feeders. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.

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- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.
- G. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.
- I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.
- K. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.
- L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- M. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- N. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes, Power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- 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. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 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.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both wall surfaces.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide ¼-inch annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

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- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

- a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice eleven (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. Test Reports: Prepare a written report to record 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.
- E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

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. 50/125 and 62.5/125-micrometer, multimode optical fiber cabling.
3. RS-232 cabling.
4. RS-485 cabling.
5. Low-voltage control cabling.
6. Control-circuit conductors.
7. Identification products.

1.3 DEFINITIONS

- A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.
- E. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- G. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- H. RCDD: Registered Communications Distribution Designer.
- I. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.

- J. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- K. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - 1. Vertical and horizontal offsets and transitions.
 - 2. Clearances for access above and to side of cable trays.
 - 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - 4. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
- C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 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 fiber flashlight] [optical loss test set] [optical fiber flashlight or optical loss test set] <Insert test>.
2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include 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.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install UTP and optical fiber 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.

PART 2 - PRODUCTS

2.1 PATHWAYS

- A. Support of Open Cabling: NRTL labeled for support of Category 5e and 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.
- B. Cable Trays:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cable Management Solutions, Inc.
 - b. Cablofil Inc.
 - c. Cooper B-Line, Inc.
 - d. Cope - Tyco/Allied Tube & Conduit.
 - e. GS Metals Corp.
 2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick.
 - a. Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - b. Trough or Ventilated Cable Trays: Nominally 6 inches (150 mm) wide.
 - c. Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).

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- d. Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
 - e. Solid-Bottom or Nonventilated Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with solid covers.
- C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
- 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.

2.2 BACKBOARDS

- A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry."

2.3 UTP 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. Mohawk; a division of Belden CDT.
 - 4. Superior Essex Inc.
- B. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
- 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 - 3. Comply with TIA/EIA-568-B.2, Category 6.
 - 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, General Purpose: Type CM or CMG.
 - b. Communications, Riser Rated: Type CMR, complying with UL 1666.
 - c. Communications, Limited Purpose: Type CMX.

2.4 UTP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Hubbell Premise Wiring.
 - 2. Orthotronics
 - 3. Leviton Voice & Data Division.

4. Panduit Corp.

- B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
- C. Connecting Blocks: 110 style for Category 5e and 110 style for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

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. ADC.
- 3. Corning Cable Systems.
- 4. American Technology Systems Industries, Inc.
- 5. Dynacom Corporation.

B. Description: Multimode, 50/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable.

- 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-492AAAA-B 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. General Purpose, Nonconductive: Type OFN or OFNG.
 - b. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
- 5. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
- 6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

- 1. Jacket Color: Aqua for 50/125-micrometer cable .
- 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.

2.6 OPTICAL FIBER CABLE HARDWARE

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

- 1. Berk-Tek; a Nexans company.

2. Corning Cable Systems.
3. Dynacom Corporation.
4. CommScope, Inc.
5. Siemon Co. (The).

B. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

1. Quick-connect, simplex and duplex, Type SC, Type ST, Type LC, Type MT-RJ connectors. Insertion loss not more than 0.75 dB.
2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.7 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.8 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM or Type CMG.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.

3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.9 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

C. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Plastic jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.10 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, Type XHHN, in raceway, complying with UL 83 and/or UL 44.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, Type XHHN, in raceway, power-limited cable, concealed in building finishes, power-limited tray cable, in cable tray, complying with UL 83 and/or UL 44.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.11 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. HellermannTyton.
 - 3. Kroy LLC.
 - 4. Panduit Corp.
- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.
- D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
- E. Cable will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows if possible.
- E. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if 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 if entering room from overhead.
 4. Extend conduits 3 inches (75 mm) above finished floor.
 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- F. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect 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. 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.
 6. 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.
 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.2.
 2. Install 110-style IDC termination hardware unless otherwise indicated.
 3. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- D. Installation of Control-Circuit Conductors:
1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- E. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (305 mm) in diameter below each feed point.

H. 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 (305 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 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 (305 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:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

- b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- 5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 - 6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.3 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

- A. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No 14 AWG.
 - 2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
 - 3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.5 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping."
- B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

- A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP 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 after 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) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - 2) Attenuation test results for 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. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR 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: Grounding systems and equipment.
- B. Section includes grounding systems and equipment, plus the following special applications:
 - 1. Overhead-line grounding.
 - 2. Underground distribution grounding.
 - 3. Ground bonding common with lightning protection system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
 - 5. Grounding for sensitive electronic equipment.
- C. Qualification Data: For qualified testing agency and testing agency's field supervisor.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.

- a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
- b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar.
- D. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression and exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad, sectional type; 3/4 inch by 10 feet (19 mm by 3 m) and 5/8 by 96 inches (16 by 2400 mm) in diameter.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING OVERHEAD LINES

- A. Comply with IEEE C2 grounding requirements.
- B. Install two parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.
- C. Drive ground rods until tops are 12 inches (300 mm) below finished grade in undisturbed earth.
- D. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.
- E. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.
- F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.
- G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
 - 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 - 10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
 - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch (6.3-by-100-by-300-mm) grounding bus.
 - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- H. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

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1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and/or indicated item, extending around the perimeter of building, area, and/or item indicated.
1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.6 LABELING

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: 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 grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- E. Grounding system will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.
- G. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
 - 5. Substations and Pad-Mounted Equipment: 5 ohms.
 - 6. Manhole Grounds: 10 ohms.
- H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR 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. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five (5) times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support 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 hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Nonmetallic slotted channel systems. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

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 installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA 4, factory-fabricated components for field assembly.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.

- f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least one (1) surface.
- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. Fabco Plastics Wholesale Limited.
 - d. Seasafe, Inc.
 - 2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 - 3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 - 4. Rated Strength: Selected to suit applicable load criteria.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- 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, 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. 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.

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- 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) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated and stainless 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: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 6. Toggle Bolts: All-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be ¼ inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least twenty-five percent (25%) in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps single-bolt conduit clamps single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1½-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1, with lock washers and nuts, 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.

- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 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.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, twenty-eight (28) day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR 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. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. LFNC: Liquidtight flexible nonmetallic conduit.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.
 2. For handholes and boxes for underground wiring, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.
 - C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 1. Structural members in the paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
 - D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." 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 cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, 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.
 - E. Qualification Data: For professional engineer and testing agency.
 - F. Source quality-control test reports.
- 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Alflex Inc.
 - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. Manhattan/CDT/Cole-Flex.
 - 7. Maverick Tube Corporation.
 - 8. O-Z Gedney; a unit of General Signal.
 - 9. Wheatland Tube Company.
- C. Rigid Steel Conduit: ANSI C80.1.
- D. Aluminum Rigid Conduit: ANSI C80.5.
- E. IMC: ANSI C80.6.
- F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit and IMC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: ANSI C80.3.
- H. FMC: Zinc-coated steel or aluminum.
- I. LFMC: Flexible steel conduit with PVC jacket.
- J. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Steel or die-cast and set-screw or compression type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- K. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Arcco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corp.; Pipe & Plastics Group.
 - 6. Condux International, Inc.
 - 7. ElecSYS, Inc.
 - 8. Electri-Flex Co.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT/Cole-Flex.
 - 11. RACO; a Hubbell Company.
 - 12. Thomas & Betts Corporation.
- C. ENT: NEMA TC 13.
- D. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- E. LFNC: UL 1660.
- F. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- G. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Arcco Corporation.
 - 2. Endot Industries Inc.
 - 3. IPEX Inc.
 - 4. Lamson & Sessions; Carlon Electrical Products.
- C. Description: Comply with UL 2024; flexible type, approved for plenum, riser, general-use installation.

2.4 METAL WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 3R, unless otherwise indicated.
- D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- E. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type, or as indicated.
- F. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hoffman.
 - 2. Lamson & Sessions; Carlon Electrical Products.
- C. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
- D. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- E. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
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. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
- B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard or custom colors.
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. Butler Manufacturing Company; Walker Division.
 - b. Enduro Systems, Inc.; Composite Products Division.
 - c. Hubbell Incorporated; Wiring Device-Kellems Division.
 - d. Lamson & Sessions; Carlon Electrical Products.
 - e. Panduit Corp.
 - f. Walker Systems, Inc.; Wiremold Company (The).
 - g. Wiremold Company (The); Electrical Sales Division.

2.7 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. RACO; a Hubbell Company.
 8. Robroy Industries, Inc.; Enclosure Division.
 9. Scott Fetzer Co.; Adalet Division.

10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

- C. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- D. Cast-Metal Outlet and Device Boxes: NEMA FB 1, cast ferrous alloy, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- F. Metal Floor Boxes: Cast iron or sheet metal, fully adjustable, rectangular.
- G. Nonmetallic Floor Boxes: Nonadjustable, round.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized cast iron with gasketed cover.
- J. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- K. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. Description: Comply with SCTE 77.
1. Color of Frame and Cover: Gray.
 2. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC." And "TELEPHONE.", or as indicated for each service.

6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 7. Handholes 2 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.
- C. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Carson Industries LLC.

- b. Christy Concrete Products.
- c. Nordic Fiberglass, Inc.

2.9 SLEEVES FOR RACEWAYS

- 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.10 SLEEVE SEALS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Stainless steel. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.11 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit, IMC, RNC, Type EPC-40-PVC, RNC, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: Rigid steel conduit, IMC, RNC, Type EPC-40-PVC, RNC, Type EPC-80-PVC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC and/or LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
6. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete and Fiberglass enclosures with polymer-concrete frame and cover, SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.
 - c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT, ENT, or RNC. Exposed, Not Subject to Severe Physical Damage: EMT, RNC identified for such use.
2. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT, or RNC, Type EPC-40-PVC.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: Rigid steel conduit.
6. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway, EMT.
7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway, EMT.
8. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway , Riser-type, optical fiber/communications cable raceway, Plenum-type, optical fiber/communications cable raceway, EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel nonmetallic in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
 - 2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.
 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- O. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
- Q. Set metal floor boxes level and flush with finished floor surface.
- R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- ### 3.3 INSTALLATION OF UNDERGROUND CONDUIT
- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Division 31 Section "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below the frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.

- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.8 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR 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:

1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct bank, and in single duct runs.
2. Handholes and pull boxes.
3. Manholes.

1.3 DEFINITION

- A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, pull boxes, and other utility structures.
4. Warning tape.
5. Warning planks.

- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder and/or step details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

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- C. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Cover design.
 - 3. Grounding details.
 - 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
- D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- E. Product Certificates: For concrete and steel used in precast concrete manholes, pull boxes, and handholes, comply with ASTM C 858.
- F. Qualification Data: For qualified professional engineer and testing agency.
- G. Source quality-control reports.
- H. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Comply with IEEE C2.
- B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

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

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1. Notify Architect and Construction Manager no fewer than two (2) days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's and Construction Manager's written permission.

1.8 COORDINATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and pull boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and pull boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.9 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.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to five percent (5%) of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. AFC Cable Systems.
 2. ARNCO Corporation.
 3. Beck Manufacturing.
 4. Cantex, Inc.
 5. CertainTeed Corp.
 6. Condux International, Inc.
 7. DCX-CHOL Enterprises, Inc.; ELECSYS Division.
 8. Electri-Flex Company.

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9. IPEX Inc.
 10. Lamson & Sessions; Carlon Electrical Products.
 11. Manhattan Wire Products; a Belden company.
- B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- C. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-120-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- D. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and retained to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
 3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
 - a. Color: Red dye added to concrete during batching.
 - b. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.3 PRECAST CONCRETE HANDHOLES AND PULL BOXES

- 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. Christy Concrete Products.
 2. Cretex Concrete Products West, Inc.; Riverton Division.
 3. Elmhurst-Chicago Stone Co.
 4. Oldcastle Precast Group.
 5. Oldcastle Precast Inc.; Utility Vault Division.
 6. Utility Concrete Products, LLC.
 7. Wausau Tile Inc.
- B. Comply with ASTM C 858 for design and manufacturing processes.
- C. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153 and ASTM A 123.
- D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.
1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing stainless-steel bolts.

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2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing stainless-steel bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing stainless-steel bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing stainless-steel bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.", "TELEPHONE.", and as indicated for each service.
7. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Extension shall provide increased depth of 12 inches.
 - b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
10. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
11. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

- A. Description: Comply with SCTE 77.

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1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering,
 - a. "ELECTRIC.", "TELEPHONE.", and as indicated for each service.
 - b. Tier level number, indicating that the unit complies with the structural load test for that tier according to SCTE 77.
 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, retained to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two (2). Handholes and pull boxes shall comply with the requirements of SCTE 77 Tier 8 and Tier 15 loading.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. Hubbell Power Systems; Lenoir City Division.
 - e. NewBasis.
- C. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Complying with SCTE 77 Tier 8 and Tier 15 loading. Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
- D. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete, complying with SCTE 77 Tier 8 and Tier 5 loading.

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1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.

E. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene, complying with SCTE 77 Light Duty loading. Cover shall be polymer concrete.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carson Industries LLC.
 - b. Nordic Fiberglass, Inc.
 - c. Pencil Plastics.

2.5 PRECAST MANHOLES

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. Christy Concrete Products.
2. Cretex Concrete Products West, Inc.; Riverton Division.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Oldcastle Precast Inc.; Utility Vault Division.
6. Utility Concrete Products, LLC.
7. Wausau Tile Inc.

B. Comply with ASTM C 858, with structural design loading as specified in "Underground Enclosure Application" Article, and with interlocking mating sections, complete with accessories, hardware, and features.

1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
2. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

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- a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
- C. Concrete Knockout Panels: 1½ to 2 inches thick, for future conduit entrance and sleeve for ground rod.
- D. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.6 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-Place Concrete."
- 1. Concrete shall have a minimum compressive strength of 3000 psi.
- C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

2.7 UTILITY STRUCTURE ACCESSORIES

- 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. Bilco Company (The).
 - 2. Campbell Foundry Company.
 - 3. Christy Concrete Products.
 - 4. Cretex Concrete Products West, Inc.; Riverton Division.
 - 5. East Jordan Iron Works.
 - 6. Elmhurst-Chicago Stone Co.
 - 7. Hubbell Power Systems; Lenoir City Division.
 - 8. McKinley Iron Works.
 - 9. Neenah Foundry Company.
 - 10. NewBasis.
 - 11. Oldcastle Precast Group.
 - 12. Oldcastle Precast Inc.; Utility Vault Division.
 - 13. Osburn Associates, Inc.
 - 14. Pennsylvania Insert Corporation.
 - 15. Underground Devices, Inc.
 - 16. Utility Concrete Products, LLC.
 - 17. Wausau Tile Inc.
- B. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM A 153 and A 123.

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- C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
 - 1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48, Class 30B with milled cover-to-frame bearing surfaces; diameter, 26 inches.
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 - 2. Cover Legend: Cast in. Retained to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - c. Legend: "SIGNAL" for communications, data, and telephone duct systems.
 - 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
- D. Manhole Sump Frame and Grate: ASTM A 48, Class 30B, gray cast iron.
- E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.
 - 1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- F. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1¼-inch-diameter eye, rated 2500-lbf minimum tension.
- G. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 - 1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- H. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; ½-inch ID by 2¾ inches deep, flared to 1¼ inches minimum at base.
 - 1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with ½-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- J. Cable Rack Assembly: Steel, hot-dip galvanized except insulators.

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1. Stanchions: T-section or channel; 2¼-inch nominal size; punched with 14 holes on 1½-inch centers for cable-arm attachment.
 2. Arms: 1½ inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
 3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- K. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine (9) holes for arm attachment.
 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.
- L. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- M. Fixed Manhole Ladders: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.
- N. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. One required.
- O. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two (2) required.
- 2.8 SOURCE QUALITY CONTROL
- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull Box Prototype Test: Test prototypes of manholes and pull boxes for compliance with SCTE 77. Strength tests shall be for specified Tier ratings of products supplied.
1. Testing Agency: Owner will engage a qualified testing agency to evaluate nonconcrete handholes and pull boxes.
 2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 CORROSION PROTECTION

- A. Aluminum shall not be installed in contact with earth or concrete.

3.2 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Cables over 600 V: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.
- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank unless otherwise indicated.
- C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- D. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- E. Underground Ducts Crossing Driveways, Roadways, and Railroads: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 or Tier 22 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf "Light-Duty" vertical loading.
- B. Manholes: Precast concrete.
 - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.5 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 25 ft. both horizontally and vertically, at other locations unless otherwise indicated.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 ft. from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 ft. outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."
- F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- G. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares.
- H. Concrete-Encased Ducts: Support ducts on duct separators.

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1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than five (5) spacers per 20 ft. of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one (1) pour is necessary, terminate each pour in a vertical plane and install ¾-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
10. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

I. Direct-Buried Duct Banks:

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1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than five (5) spacers per 20 ft. of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND PULL BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1½- to 2- inches-thick, arranged as indicated.

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3. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."
- B. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
 2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
 2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
 3. Install handholes with bottom below the frost line, below grade.
 4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
 5. Where indicated, cast handhole cover frame integrally with handhole structure.
- D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three (3) days. Waterproofing materials and installation are specified in Division 07. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three (3) days.
- G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two (2) anchors for each cable stanchion.

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- J. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.7 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use pull box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level 6-inch-thick bed of crushed stone or gravel, graded from ½-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: Set so cover surface will be flush with finished grade.
- D. Install handholes and pull boxes with bottom below the frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Retain arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi, twenty-eight (28) day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.

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2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to eighty percent (80%) fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR 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. This Section includes the following:

- 1. Isolation pads.
- 2. Spring isolators.
- 3. Restrained spring isolators.
- 4. Channel support systems.
- 5. Restraint cables.
- 6. Hanger rod stiffeners.
- 7. Anchorage bushings and washers.

- B. Related Sections include the following:

- 1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:

- 1. Site Class as Defined in the IBC: E.
- 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
 - a. Component Importance Factor: 1.5.
 - b. Component Response Modification Factor: 5.5.
 - c. Component Amplification Factor: 1.0.
- 3. Design Spectral Response Acceleration at Short Periods (0.2 Second).

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. 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 agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.
2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. 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 agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control test reports.

1.7 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.
- E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.
 - 7. Vibration Eliminator Co., Inc.
 - 8. Vibration Isolation.
 - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Cooper B-Line, Inc.; a division of Cooper Industries.
 4. Hilti Inc.
 5. Loos & Co.; Seismic Earthquake Division.
 6. Mason Industries.
 7. TOLCO Incorporated; a brand of NIBCO INC.
 8. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
- G. 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.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: 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.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. 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.
- 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 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on 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.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
 - 1. Install restrained isolators on electrical equipment.
 - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- 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. 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.
- D. 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.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 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 postconnection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR 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:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

- H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- I. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- D. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

- A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- B. Furnish and install tape at location in accordance with NEC 110.26 for all electrical distribution equipment.**

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 4 mils (0.1 mm).
3. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).

D. Tag: Type II:

1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 12 mils (0.3 mm).
3. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).

E. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 5 mils (0.125 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
5. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

F. Tag: Type IID:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 8 mils (0.2 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
5. 3-Inch (75-mm) Tensile According to ASTM D 882: 300 lbf (1334 N), and 12,500 psi (86.1 MPa).

2.7 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Baked-Enamel Warning Signs:
 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 3. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs:
 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 3. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:
 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.8 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.

- 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- 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.

2.9 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- B. 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.
- C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.10 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black.

- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - 5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

2.12 DATA RECEPTACLES

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. It should read "DATA ONLY". Minimum letter height shall be 3/8 inch (10 mm).
- B. 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.
- C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm)

2.13 RECEPTACLES ON EMERGENCY POWER

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in orange, 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. Install orange labwl with receptacle device for identification.

2.14 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
- J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend

"DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 30-foot (10-m) maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot (10-m) maximum intervals.
- D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Emergency Power.
 2. Power.
 3. UPS.
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

- F. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags, nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.
- G. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- H. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - 1. Limit use of underground-line warning tape to direct-buried cables.
 - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
- M. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

- N. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.

- O. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label [Stenciled legend 4 inches (100 mm) high.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

 - 2. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive and engraved laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchgear.
 - e. Switchboards.
 - f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - g. Substations.
 - h. Emergency system boxes and enclosures.
 - i. Motor-control centers.
 - j. Enclosed switches.
 - k. Enclosed circuit breakers.
 - l. Enclosed controllers.
 - m. Variable-speed controllers.
 - n. Push-button stations.
 - o. Power transfer equipment.
 - p. Contactors.
 - q. Remote-controlled switches, dimmer modules, and control devices.
 - r. Battery-inverter units.
 - s. Battery racks.
 - t. Power-generating units.

- u. Monitoring and control equipment.
- v. UPS equipment.

END OF SECTION 260553

SECTION 260573 - 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 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and Equipment Evaluation Reports.
 - 3. Coordination-Study Report.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For coordination-study specialist.
- B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

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.

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

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. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide [**the product indicated on Drawings**] or a comparable product by one of the following:
 1. CGI CYME.
 2. EDSA Micro Corporation.
 3. ESA Inc.
 4. Operation Technology, Inc.
 5. SKM Systems Analysis, Inc.

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 electrical 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 141] [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.
 - 2. Medium-Voltage Circuit Breakers: IEEE C37.010.
 - 3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
 - 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

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
 - 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 141] [IEEE 241] [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 values.
 - 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.

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

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.

END OF SECTION 260573

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following lighting control devices:

1. Time switches.
2. Outdoor and indoor photoelectric switches.
3. Indoor occupancy sensors.
4. Outdoor motion sensors.
5. Lighting contactors.
6. Emergency shunt relays.

- B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.
2. Division 26 Section "Interior Lighting" for theatrical lighting controls.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product 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.

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

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

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Leviton Mfg. Company Inc.
5. Lightolier Controls; a Genlyte Company.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Paragon Electric Co.; Invensys Climate Controls.
8. Square D; Schneider Electric.
9. TORK.
10. Touch-Plate, Inc.
11. Watt Stopper (The).

- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: SPST, DPST, and DPDT.
2. Contact Rating: 30-A inductive or resistive, 240-V ac, and 20-A ballast load, 120/240-V ac.
3. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
4. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
5. Programs: channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
6. Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.
7. Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.

8. Programs: channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
9. Programs: channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.
10. Program: an annual holiday schedule that overrides the weekly operation on holidays.
11. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
12. Astronomic Time: All channels.
13. Battery Backup: For schedules and time clock.

C. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Configuration: SPST, DPST, SPDT, and DPDT.
2. Contact Rating: 30-A inductive or resistive, 240-V ac, 20-A ballast load, 120/240-V ac.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
4. Astronomic time dial.
5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
6. Skip-a-day mode.
7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

B. Description: Solid state, with SPST and DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- C. Description: Solid state, with SPST and DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
 2. Time Delay: 30-second minimum, to prevent false operation.
 3. Lightning Arrester: Air-gap type.
 4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR PHOTOELECTRIC SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. Area Lighting Research, Inc.; Tyco Electronics.
 3. Eaton Electrical Inc; Cutler-Hammer Products.
 4. Grasslin Controls Corporation; a GE Industrial Systems Company.
 5. Intermatic, Inc.
 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. MicroLite Lighting Control Systems.
 8. Novitas, Inc.
 9. Paragon Electric Co.; Invensys Climate Controls.
 10. Square D; Schneider Electric.
 11. TORK.
 12. Touch-Plate, Inc.
 13. Watt Stopper (The).
 - 14.
- B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 3. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn-on and turn-off levels within that range.
 4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 4. Novitas, Inc.
 5. RAB Lighting, Inc.
 6. Sensor Switch, Inc.
 7. TORK.
 8. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.
- D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.5 OUTDOOR MOTION SENSORS (PIR)

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

1. Bryant Electric; a Hubbell Company.
2. Hubbell Lighting.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Paragon Electric Co.; Invensys Climate Controls.
5. RAB Lighting, Inc.
6. TORK.
7. Watt Stopper (The).

B. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as raintight according to UL 773A.

1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
 - b. Relay: Internally mounted in a standard weatherproof electrical enclosure.

- c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 3. Bypass Switch: Override the on function in case of sensor failure.
 - 4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc (11 to 215 lx); keep lighting off during daylight hours.
- C. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
- D. Detection Coverage: Up to 35 feet (11 m), with a field of view of 90 degrees.
- E. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
- F. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - 1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - 2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

2.6 LIGHTING CONTACTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Allen-Bradley/Rockwell Automation.
 - 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
 - 3. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 4. GE Industrial Systems; Total Lighting Control.
 - 5. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 6. Hubbell Lighting.
 - 7. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 8. MicroLite Lighting Control Systems.
 - 9. Square D; Schneider Electric.
 - 10. TORK.
 - 11. Touch-Plate, Inc.
 - 12. Watt Stopper (The).
- B. Description: Electrically operated and electrically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
 - 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.
 4. Provide with control and pilot devices as indicated on Drawings and schedule, matching the NEMA type specified for the enclosure.
- C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
1. Monitoring: On-off status.
 2. Control: On-off operation.

2.7 EMERGENCY SHUNT RELAY

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. LVS, Inc.
 2. Sensor Switch
 3. Watt Stopper
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts (dual-contact where required); complying with UL 924.
1. Coil Rating: 120-277 V or as indicated on drawings.

2.8 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 260923

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.
8. Mimic bus.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards 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."

1.4 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.

4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 6. Detail utility company's metering provisions with indication of approval by utility company.
 7. Include evidence of NRTL listing for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 10. Include diagram and details of proposed mimic bus.
 11. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Qualification Data: For qualified Installer and testing agency.
- E. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." 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.
- F. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Comply with NEMA PB 2.
- G. Comply with NFPA 70.
- H. Comply with UL 891.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.
- C. Handle and prepare switchboards for installation according to NECA 400 and/or NEMA PB 2.1.

1.7 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 - 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

- a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
- 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).
- D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
- 1. Notify Architect and Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.
 - 3. Do not proceed with interruption of electric service without Architect's and Construction Manager's written permission.
 - 4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.10 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Front-Connected, Front-Accessible Switchboards:
 1. Main Devices: Panel and Fixed, individually mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- D. Front- and Side-Accessible Switchboards:
 1. Main Devices: Fixed, individually mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- E. Front- and Rear-Accessible Switchboards:
 1. Main Devices: Fixed, individually and Drawout mounted.
 2. Branch Devices: Fixed and individually compartmented mounted.
 3. Sections front and/or rear aligned.
- F. Nominal System Voltage: 480/277 V.
- G. Main-Bus Continuous: 2000A.
- H. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

- I. Indoor Enclosures: Steel, NEMA 250, Type 1
- J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
 - 1. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be 120/208-V ac.
 - 2. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
- K. Barriers: Between adjacent switchboard sections.
- L. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- M. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
- N. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- O. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- P. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.
- Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- R. Pull Box on Top of Switchboard:
 - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 - 2. Set back from front to clear circuit-breaker removal mechanism.
 - 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 - 4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- S. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated,]with tin-plated aluminum or copper feeder circuit-breaker line connections.

2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, or tin-plated, high-strength, electrical-grade aluminum alloy.
 4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 5. Ground Bus: [1/4-by-2-inch- (6-by-50-mm-)] [1/4-by-1-inch- (6-by-25-mm-)] Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 6. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 7. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- U. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- V. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings or comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating

matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 7. LED indicator lights for power and protection status.
 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 10. Six-digit, transient-event counter set to totalize transient surges.
- D. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
- E. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- F. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:
1. Line to Neutral: 1200 V for 480Y/277.
 2. Line to Ground: 1200 V for 480Y/277.
 3. Neutral to Ground: 1200 V for 480Y/277.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

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5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time time adjustments.
 - c. Ground-fault pickup level, time delay, and I^2t response.
 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 5. Remote trip indication and control.
 6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

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7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 8. Control Voltage: 40-V dc and/or 120-V ac.
- C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Boltswitch, Inc.
 - b. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - c. Pringle Electrical Manufacturing Company, Inc.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 5. Service-Rated Switches: Labeled for use as service equipment.
 6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
 - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
 7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- D. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 5. Service-Rated Switches: Labeled for use as service equipment.
 6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - a. Configuration: Integrally mounted and/or Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
 - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
 7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- E. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- F. Fuses are specified in Division 26 Section "Fuses."

2.4 INSTRUMENTATION

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

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3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.
- C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
1. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semi-flush, with antiparallax 250-degree scales and external zero adjustment.
 2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
- D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- E. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- F. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.

2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

G. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five 15 minute integrated demand of totalized system.

2.5 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Control Circuits: 120-V ac, supplied from remote branch circuit.
- C. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- D. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- E. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

- B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.7 IDENTIFICATION

- A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
 - 1. Nameplate: At least 0.032-inch- (0.813-mm-) thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
- B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
 - 1. Nameplate: At least 0.0625-inch- (1.588 mm-) thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
- C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
- D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. 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 (450-mm) centers around the full perimeter of concrete 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 elevations required for proper attachment to switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install filler plates in unused spaces of panel-mounted sections.
- G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install spare-fuse cabinet.
- I. Comply with NECA 1.

3.3 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and/or rear panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Switchboard will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.
 - 4. Electronic-grade panelboards.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards 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."

1.5 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." 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.

E. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C) 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect and Construction Manager Owner no fewer than two days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Architect's and Construction Manager's written permission.

3. Comply with NFPA 70E.

1.9 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

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. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush- and surface-mounted cabinets.
 1. Rated for environmental conditions at installed location.

- a. Indoor Dry and Clean Locations: NEMA 250
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 or Type 12.
2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 6. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Top and bottom.
- D. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 5. Split Bus: Vertical buses divided into individual vertical sections.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 6. Gutter-Tap Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

- 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Panelboards: NEMA PB 1, power and feeder distribution type.
- D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- E. Mains: Circuit breaker, Fused switch, and Lugs only.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in Bolt-on circuit breakers.
- G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- H. Branch Overcurrent Protective Devices: Fused switches.
- I. Contactors in Main Bus: NEMA ICS 2, Class A, electrically and/or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- D. Mains: Circuit breaker or lugs only.
- E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically and/or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. External Control-Power Source: 120-V branch circuit.
- G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 LOAD CENTERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.

- C. Load Centers: Comply with UL 67.
- D. Mains: Circuit breaker and Lugs only.
- E. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- F. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.5 ELECTRONIC-GRADE PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Current Technology; a subsidiary of Danahar Corporation.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 4. Liebert Corporation.
 - 5. Siemens Energy & Automation, Inc.
 - 6. Square D; a brand of Schneider Electric.
- C. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
- D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- E. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- F. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- G. Buses:
 - 1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
 - 2. Copper equipment and isolated ground buses.
- H. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.
 - 1. Accessories:
 - a. Fuses rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.

- e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. [Four] [Six]-digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
 3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - a. Line to Neutral: 70,000 A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.
 4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
 5. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V for 208Y/120.
 - b. Line to Ground: 400 V for 208Y/120.
 - c. Neutral to Ground: 400 V for 208Y/120.
 6. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V.
 - b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.
 7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
 - a. Line to Neutral: 400 V, 800 V from high leg.
 - b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.
 8. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
 - a. Line to Line: 1000 V for 240 V.
 - b. Line to Ground: 800 V for 240 V.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 - 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression and Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

- f. Shunt Trip: 120 and/or 24 V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
- h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
- i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
- j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- k. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
- l. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
- m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
- n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

- 1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
- 2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
- 3. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

2.7 PANELBOARD SUPPRESSORS

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

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

- 1. Current Technology; a subsidiary of Danahar Corporation.
- 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
- 4. Liebert Corporation.
- 5. Siemens Energy & Automation, Inc.
- 6. Square D; a brand of Schneider Electric.

C. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:
 - a. LED indicator lights for power and protection status.
 - b. Audible alarm, with silencing switch, to indicate when protection has failed.
 - c. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.

D. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:
 - a. Fuses rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. Six-digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - a. Line to Neutral: 70,000 A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.
4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
5. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V for 208Y/120.
 - b. Line to Ground: 400 V for 208Y/120.
 - c. Neutral to Ground: 400 V for 208Y/120.
6. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V.

- b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.
7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
- a. Line to Neutral: 400 V, 800 V from high leg.
 - b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.
8. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
- a. Line to Line: 1000 V for 240 V.
 - b. Line to Ground: 800 V for 240 V.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NECA 407 and/or NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NECA 407 and/or NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. 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 (450-mm) centers around full perimeter of base.
 2. For panelboards, 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 panelboards.
 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Mount top of trim [90 inches (2286 mm) above finished floor unless otherwise indicated.
- F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
1. Set field-adjustable, circuit-breaker trip ranges.
- H. Install filler plates in unused spaces.
- I. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- K. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Panelboards will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

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 utility company and 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 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.
- C. Field quality-control reports.
- D. Operation and Maintenance Data. In addition to items specified in Division 01 Section "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.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, store, and handle modular meter center according to NECA 400.

1.7 PROJECT CONDITIONS

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

1.8 COORDINATION

- A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
 - 1. Comply with requirements of utilities providing electrical power services.
 - 2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.9 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. 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 his computer equipment if necessary.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

- A. Meters will be furnished by utility company.
- B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- C. Meter Sockets: Comply with requirements of electrical-power utility company.
- D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.
- E. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only and/or disconnect device, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D; a brand of Schneider Electric.
 - 3. Comply with requirements of utility company for meter center.
 - 4. Housing: NEMA 250, Type 3R enclosure.
 - 5. 100,000 A symmetrical at rated voltage.
 - 6. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.
 - 7. Main Disconnect Device: Fusible switch, series-combination rated by circuit-breaker manufacturer to protect downstream feeder and branch circuit breakers.
 - 8. Tenant Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect circuit breakers in downstream tenant and to house loadcenters and panelboards that have 22,000-A interrupting capacity.
 - a. Identification: Complying with requirements in Division 26 Section "Identification for Electrical Systems" with legend identifying tenant's address.
 - b. Physical Protection: Tamper resistant, with hasp for padlock.
 - 9. Meter Socket: Rating coordinated with indicated tenant feeder circuit rating.
 - 10. Surge Protection: For main disconnect device, comply with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."

2.2 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. E-Mon; a division of Hunt Power.
 2. National Meter Industries.
 3. Osaki Meter Sales, Inc.
 4. Square D; a brand of Schneider Electric.
- C. General Requirements for Owner's Meters:
1. Comply with UL 1244.
 2. Meters used for billing shall have an accuracy of 1.0 percent of reading, complying with requirements in ANSI C12.20.
 3. Enclosure: NEMA 250, Type 3R minimum, with hasp for padlocking or sealing.
 4. Identification: Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 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 and solid core.
 7. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
 8. 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.
- D. Kilowatt-hour Meter: Electronic single- and three-phase meters, measuring electricity used.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
 3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.
- E. Kilowatt-hour/Demand Meter: Electronic single- and 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.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak

demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.

- F. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."
- G. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing.
 - 1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:
 - a. At least 15 departments.
 - b. At least 30 tenants.
 - c. At least five processes.
 - d. At least five buildings.
 - 2. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
 - 2. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant's name.

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 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Twist-locking receptacles.
 - 3. Receptacles with integral surge suppression units.
 - 4. Wall-box motion sensors.
 - 5. Isolated-ground receptacles.
 - 6. Snap switches and wall-box dimmers.
 - 7. Solid-state fan speed controls.
 - 8. Wall-switch and exterior occupancy sensors.
 - 9. Communications outlets.
 - 10. Pendant cord-connector devices.
 - 11. Cord and plug sets.
 - 12. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.
- B. Related Sections include the following:
 - 1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).
- B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CR 5253IG.
 - b. Leviton; 5362-IG.
 - c. Pass & Seymour; IG6300.
 3. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
- C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; TR8300.
 - b. Hubbell; HBL8300SG.
 - c. Leviton; 8300-SGG.
 - d. Pass & Seymour; 63H.
 3. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.

2.4 TVSS RECEPTACLES

- A. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
 - 1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
 - 2. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
- B. Duplex TVSS Convenience Receptacles:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5362BLS.
 - b. Hubbell; HBL5362SA.
 - c. Leviton; 5380.
 - 3. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
- C. Isolated-Ground, Duplex Convenience Receptacles:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; IG5362BLS.
 - b. Hubbell; IG5362SA.
 - c. Leviton; 5380-IG.
 - 3. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
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. Cooper Crouse-Hinds.
 - b. EGS/Appleton Electric.
 - c. Killark; a division of Hubbell Inc.

2.6 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; L520R.
 - b. Hubbell; HBL2310.
 - c. Leviton; 2310.
 - d. Pass & Seymour; L520-R.
- B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; IG2310.
 - b. Leviton; 2310-IG.
 3. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.7 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.8 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20 A:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 3. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

- D. Key-Operated Switches, 120/277 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2L.
 - d. Pass & Seymour; PS20AC1-L.
 3. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.
 - b. Hubbell; HBL1557.
 - c. Leviton; 1257.
 - d. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995L.
 - b. Hubbell; HBL1557L.
 - c. Leviton; 1257L.
 - d. Pass & Seymour; 1251L.

2.10 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."

- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.11 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.

1. Continuously adjustable rotary knob, 5 A.
2. Three-speed adjustable slider, 1.5 A.

2.12 OCCUPANCY SENSORS

- A. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 6111 for 120 V, 6117 for 277 V.
 - b. Hubbell; WS1277.
 - c. Leviton; ODS 10-ID.
 - d. Pass & Seymour; WS3000.
 - e. Watt Stopper (The); WS-200.
3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

- B. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; AT120 for 120 V, AT277 for 277 V.
 - b. Leviton; ODS 15-ID.
3. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

- C. Long-Range Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

- a. Hubbell; ATP1600WRP.
 - b. Leviton; ODWWV-IRW.
 - c. Pass & Seymour; WA1001.
 - d. Watt Stopper (The); CX-100.
3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
- D. Long-Range Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATD1600WRP.
 - b. Leviton; ODW12-MRW.
 - c. Watt Stopper (The); DT-200.
 3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).
- E. Wide-Range Wall-Switch Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATP120HBRP.
 - b. Leviton; ODWHB-IRW.
 - c. Pass & Seymour; HS1001.
 - d. Watt Stopper (The); CX-100-3.
 3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
- F. Exterior Occupancy Sensors:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; PS200-10.
 - b. Watt Stopper (The); EW-100-120.
 3. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot (34-m) detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.13 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.14 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Stainless, tamper resistant with trident pan head matching current building standard.
2. Material for Finished Spaces: Brushed stainless.
3. Material for Unfinished Spaces: Brushed stainless for flush box installations, raised galvanized for surface box installations.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet locations while in use.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, thermoplastic with lockable cover.

2.15 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, solid brass with satin finish.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

- E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable.

2.16 POKE-THROUGH ASSEMBLIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 - 3. Square D/ Schneider Electric.
 - 4. Thomas & Betts Corporation.
 - 5. Wiremold Company (The).
- C. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 - 1. Service Outlet Assembly: Flush type with two simplex receptacles and space for two RJ-45 jacks.
 - 2. Size: Selected to fit nominal 3-inch (75-mm) cored holes in floor and matched to floor thickness.
 - 3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
 - 4. Closure Plug: Arranged to close unused 3-inch (75-mm) cored openings and reestablish fire rating of floor.
 - 5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category 6 voice and data communication cables.

2.17 MULTIOUTLET ASSEMBLIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Wiremold Company (The).
- C. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- D. Raceway Material: Metal, with manufacturer's standard finish.
- E. Wire: No. 12 AWG.

2.18 SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
1. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
 2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
 3. Finishes: Manufacturer's standard painted finish and trim combination.
 4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
 5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
 6. Voice and Data Communication Outlets: Two RJ-45 Category 5e jacks] [Four RJ-45 Category 5e jack.

2.19 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
1. Wiring Devices Connected to Normal Power System: Ivory and/or as selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
 2. Wiring Devices Connected to Emergency Power System: Red.
 3. TVSS Devices: Blue.
 4. Isolated-Ground Receptacles: Orange and/or as specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailling existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install GFCI devices in all wet locations.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up and/or down, and on horizontally mounted receptacles to the right and/or left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
 - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
 - 2. Test Instruments: Use instruments that comply with UL 1436.
 - 3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- B. Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Test straight blade convenience outlets in patient-care areas and hospital-grade convenience outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, enclosed controllers and motor-control centers.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches.
3. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
4. Spare-fuse cabinets.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Fuse sizes for elevator feeders and elevator disconnect switches.

- B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.7 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 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. Cooper Bussmann, Inc.
 - 2. Edison Fuse, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 PLUG FUSES

- A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.4 PLUG-FUSE ADAPTERS

- A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Feeders: Class J, fast acting.
 - 2. Motor Branch Circuits: Class RK1, time delay.
 - 3. Other Branch Circuits: Class J, fast acting.
 - 4. Control Circuits: Class CC, fast acting.
- B. Plug Fuses:
 - 1. Motor Branch Circuits: Edison-base type, single-element time delay.
 - 2. Other Branch Circuits: Edison-base type, single-element fast acting.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.
- C. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Receptacle switches.
 - 4. Shunt trip switches.
 - 5. Molded-case circuit breakers (MCCBs).
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers 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."

1.5 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1. Enclosure types and details for types other than NEMA 250, Type 1.
 2. Current and voltage ratings.
 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 4. Include evidence of NRTL listing for series rating of installed devices.
 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
1. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Seismic Qualification Certificates: For enclosed switches and circuit breakers, 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.
- E. Field quality-control reports.
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.
- 1.6 QUALITY ASSURANCE
- A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m).
- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 1. Notify Architect and Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
 2. Indicate method of providing temporary electric service.
 3. Do not proceed with interruption of electric service without Architect and Construction Manager written permission.
 4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.9 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.
- 3.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Type HD, Heavy Duty, Single Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac and 240-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Double Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 6. Hookstick Handle: Allows use of a hookstick to operate the handle.

7. Lugs: Mechanical and/or Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Type HD, Heavy Duty, Single Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac and 240-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Double Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
 6. Lugs: Mechanical and/or Compression type, suitable for number, size, and conductor material.

2.3 RECEPTACLE SWITCHES

- 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:

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac and 240-V ac, 100 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 600-V ac and 240-V ac, 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- E. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- F. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

SHUNT TRIP SWITCHES

- G. 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:
- H. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Cooper Bussmann, Inc.
 - 2. Ferraz Shawmut, Inc.
 - 3. Littelfuse, Inc.
- I. General Requirements: Comply with [ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
- J. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- K. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, Of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
- L. Accessories:
 - 1. Oiltight key switch for key-to-test function.

2. Oiltight green ON pilot light.
3. Isolated neutral lug; 200 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac and/or 24-V dc coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- D. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- E. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- F. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 1. Instantaneous trip.
 2. Long- and short-time pickup levels.
 3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I^2t response.
- G. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- H. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- I. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

- J. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- K. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical and/or Compression type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Communication Capability: Circuit-breaker-mounted and Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring and Control."
 - 6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 9. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
 - 10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 11. Zone-Selective Interlocking: Integral with electronic and/or ground-fault trip unit; for interlocking ground-fault protection function.
 - 12. Electrical Operator: Provide remote control for on, off, and reset operations.

2.5 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- D. Features and Accessories:
 - 1. Standard frame sizes and number of poles.

2. Lugs: Mechanical and/or Compression type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac and 24-V dc.

2.6 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Kitchen and/or Wash-Down Areas: NEMA 250, Type 4X.
 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 6. Hazardous Areas Indicated on Drawings: NEMA 250, [Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and

- circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified

END OF SECTION 262816

SECTION 262913 - ENCLOSED CONTROLLERS

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 enclosed controllers rated 600 V and less:
 - 1. Full-voltage manual.
 - 2. Full-voltage magnetic.
 - 3. Reduced-voltage magnetic.
 - 4. Reduced-voltage solid state.
 - 5. Multispeed.
- B. Related Section:
 - 1. Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon-controlled rectifier.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed controllers 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."

1.5 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 1. Show tabulations of the following:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Nameplate legends.
 - d. Short-circuit current rating of integrated unit.
 - e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Seismic Qualification Certificates: For enclosed controllers, 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.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Routine maintenance requirements for enclosed controllers and installed components.
 2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 3. Manufacturer's written instructions for setting field-adjustable overload relays.
 4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

- G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.
- D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; connect factory-installed space heaters to temporary electrical service.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).
- B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect and Construction Manager no fewer than two days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical systems without Architect's and Construction Manager's written permission.
4. Comply with NFPA 70E.

1.9 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.10 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. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Indicating Lights: Two of each type and color installed.
 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawing or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing and/or Two speed.
 4. Surface mounting.
 5. Green pilot light.
 6. Additional Nameplates: FORWARD and REVERSE for reversing switches and/or HIGH and LOW for two-speed switches.
- C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing and/or Two speed.
 4. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button melting alloy type.
 5. Surface mounting.
 6. Green pilot light.
 7. Additional Nameplates: HIGH and LOW for two-speed controllers.
- D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.

- d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
3. Configuration: Nonreversing and/or Two speed.
 4. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button melting alloy type.
 5. Surface mounting.
 6. Green pilot light.
 7. Additional Nameplates: FORWARD and REVERSE for reversing switches and/or HIGH and LOW for two-speed switches.
 8. N.C. auxiliary contact.
- E. Magnetic Controllers: Full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing.
 4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 5. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 6. Control Circuits: 24 and/or 120-V ac; obtained from integral CPT, with primary and secondary fuses with control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 100 VA.
 7. Melting Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 8. Bimetallic Overload Relays:

- a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
9. Solid-State Overload Relay:
- a. Switch or dial selectable for motor running overload protection.
 - b. Sensors in each phase.
 - c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
10. N.O., isolated overload alarm contact.
11. External overload reset push button.
- F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 4. Nonfusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 5. MCP Disconnecting Means:

- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. N.O. alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
6. MCCB Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e. N.O. alarm contact that operates only when MCCB has tripped.

2.2 REDUCED-VOLTAGE MAGNETIC CONTROLLERS

- A. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
- B. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration:
 - a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
 - b. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.

- c. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
 - 4. Contactor Coils: Pressure-encapsulated type with coil transient suppressor.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - 5. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - 6. Control Circuits: 24 and/or 120-V ac; obtained from integral CPT, with primary and secondary fuses and control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 100 VA.
 - 7. Melting Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 8. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
 - 9. Solid-State Overload Relay:
 - a. Switch or dial selectable for motor running overload protection.
 - b. Sensors in each phase.
 - c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
 - 10. N.O., isolated overload alarm contact.
 - 11. External overload reset push button.
- C. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
3. Fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
4. Nonfusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
5. MCP Disconnecting Means:
 - a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. N.O. alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
6. MCCB Disconnecting Means:
 - a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

- c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
- e. [N.C.] [N.O.] alarm contact that operates only when MCCB has tripped.

2.3 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS

- A. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
- B. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Severe duty nonreversible.
 4. Starting Mode: Voltage ramping and Torque control with voltage boost; field selectable.
 5. Stopping Mode: Coast to stop; field selectable.
 6. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
 7. Shorting[and Input Isolation Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating.[Provide coil transient suppressors.]
 8. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
 9. Control Circuits: 24 and/or 120-V ac; obtained from integral CPT, with primary and secondary fuses, with control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 100 VA.
 10. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
 11. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with external feedback from the motor or driven equipment.

12. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
 - a. Adjusting motor full-load amperes, as a percentage of the controller's rating.
 - b. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
 - c. Adjusting linear acceleration and deceleration ramps, in seconds.
 - d. Initial torque, as a percentage of the nominal motor torque.
 - e. Adjusting torque limit, as a percentage of the nominal motor torque.
 - f. Adjusting maximum start time, in seconds.
 - g. Adjusting voltage boost, as a percentage of the nominal supply voltage.
 - h. Selecting stopping mode, and adjusting parameters.
 - i. Selecting motor thermal overload protection class between 5 and 30.
 - j. Activating and de-activating protection modes.
 - k. Selecting or activating communication modes.

13. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
 - a. Controller Condition: Ready, starting, running, stopping.
 - b. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
 - c. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
 - d.

14. Controller Diagnostics and Protection:
 - a. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 - b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
 - c. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.
 - d. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
 - e. <

15. Remote Output Features:
 - a. All outputs prewired to terminal blocks.
 - b. Form C status contacts that change state when controller is running.
 - c. Form C alarm contacts that change state when a fault condition occurs.

16. Optional Features:

-
- a. Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc.
 - b. Additional field-assignable Form C contacts, as indicated, for alarm outputs.
 - c. Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 - d. Full-voltage bypass contactor operating automatically. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
 - e. Melting Alloy Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10 tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - f. Bimetallic Overload Relays:
 - 1) Inverse-time-current characteristic.
 - 2) Class 10] tripping characteristic.
 - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - 4) Ambient compensated.
 - 5) Automatic resetting.
 - g. Solid-State Overload Relay:
 - 1) Switch or dial selectable for motor running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10/20 selectable] tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - h. N.O., isolated overload alarm contact.
 - i. External overload reset push button.
- C. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.

- d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
3. Fusible Disconnecting Means:
- a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
4. MCP Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. [N.C.] [N.O.] alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
5. MCCB Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e. N.O. alarm contact that operates only when MCCB has tripped.
6. Molded-Case Switch Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
 - d. [N.C.] [N.O.] alarm contact that operates only when molded-case switch has tripped.

2.4 MULTISPEED MAGNETIC CONTROLLERS

- A. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing.
 4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 5. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 6. Control Circuits: 24 and/or 120-V ac; obtained from integral CPT, with primary and secondary fuses control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 100 VA.
 7. Compelling relays shall ensure that motor will start only at low speed.
 8. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
 9. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
 10. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
 11. Melting Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 12. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.

- b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
13. Solid-State Overload Relay:
- a. Switch or dial selectable for motor running overload protection.
 - b. Sensors in each phase.
 - c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
14. N.O., isolated overload alarm contact.
15. External overload reset push button.
- C. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 - 3. Fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate [Class J] [Class R] [indicated] fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - 4. Nonfusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 - 5. MCP Disconnecting Means:

- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
 - d. N.O. alarm contact that operates only when MCP has tripped.
 - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
6. MCCB Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
 - e. N.O. alarm contact that operates only when MCCB has tripped.

2.5 ENCLOSURES

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
 2. Outdoor Locations: Type 3R.
 3. Kitchen and/or Wash-Down Areas: Type 4X, stainless steel.
 4. Other Wet or Damp Indoor Locations: Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
 6. Hazardous Areas Indicated on Drawings: Type 9.

2.6 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
1. Push Buttons, Pilot Lights, and Selector Switches: Heavy, oil light type.
 - a. Push Buttons: Recessed types; maintained as indicated.
 - b. Pilot Lights: LED types; colors as indicated push to test.
 - c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable.
 3. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
- B. N.O. auxiliary contact(s).
 - C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
 - D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 - E. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 and/or Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
 - F. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
 - G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
 - H. Cover gaskets for Type 1 enclosures.
 - I. Terminals for connecting power factor correction capacitors to the load side of overload relays.
 - J. Spare control wiring terminal blocks, quantity as indicated; wired.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-

steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

- B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness 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 (450-mm) centers around the full perimeter of concrete 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 elevations required for proper attachment to supported equipment.
- C. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in each fusible-switch enclosed controller.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Install power factor correction capacitors. Connect to the load side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
- J. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
 - 2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Construction Manager before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect and Construction Manager before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers at 80 percent.
- E. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.
- F. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers.

END OF SECTION 262913

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

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 separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
- B. Related Sections:
 - 1. Division 26 Section "Motor-Control Centers" for VFCs installed in motor-control centers.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. CE: Conformance Europeene (European Compliance).
- C. CPT: Control power transformer.
- D. EMI: Electromagnetic interference.
- E. IGBT: Insulated-gate bipolar transistor.
- F. LAN: Local area network.
- G. LED: Light-emitting diode.
- H. MCP: Motor-circuit protector.
- I. NC: Normally closed.
- J. NO: Normally open.
- K. OCPD: Overcurrent protective device.
- L. PCC: Point of common coupling.
- M. PID: Control action, proportional plus integral plus derivative.

- N. PWM: Pulse-width modulated.
- O. RFI: Radio-frequency interference.
- P. TDD: Total demand (harmonic current) distortion.
- Q. THD(V): Total harmonic voltage demand.
- R. VFC: Variable-frequency motor controller.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: VFCs 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."

1.5 SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.
- C. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Enclosure types and details.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of enclosed unit.
 - f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
 - g. Specified modifications.
 - 2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

- D. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC to specified levels.
 - E. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
 - F. Seismic Qualification Certificates: For VFCs, 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.
 - G. Product Certificates: For each VFC, from manufacturer.
 - H. Source quality-control reports.
 - I. Field quality-control reports.
 - J. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
 - 2. Manufacturer's written instructions for setting field-adjustable overload relays.
 - 3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - 4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - K. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
 - L. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.
- 1.6 QUALITY ASSURANCE
- A. Testing Agency Qualifications: Member company of NETA or an NRTL.

VARIABLE FREQUENCY MOTOR CONTROLLERS

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.
- D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and connect factory-installed space heaters to temporary electrical service.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.
 2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
 3. Humidity: Less than 95 percent (noncondensing).
 4. Altitude: Not exceeding 3300 feet (1005 m).

1.9 COORDINATION

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

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

1.11 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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3. Indicating Lights: Two of each type and color installed.
 - 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Refer to sections 2.5 through 2.9 of specification section 262419 “Motor-Control Centers” for general VFC requirements.

2.2 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: Type 1.
 - 2. Outdoor Locations: Type 3R.
 - 3. Kitchen Areas: Type 4X, stainless steel.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.3 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
 - 1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
 - 1. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories."
 - 2. Structural-steel channels are specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- D. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Install fuses in each fusible-switch VFC.
- G. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

- I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- J. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 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. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 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.

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect and Construction Manager before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 263213 - ENGINE GENERATORS

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 relocation of packaged engine-generator sets for emergency power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Performance requirements for sensitive loads.
 - 5. Outdoor sound attenuated enclosure.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS

- A. Shop Drawings: Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For installer manufacturer and testing agency.

- B. Field quality-control test reports.
- C. Warranty: Applicable only to any new materials and all workmanship related to this section.

1.6 CLOSEOUT SUBMITTALS

- A. Startup and testing results.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
 - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- 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 ASME B15.1.
- E. Comply with NFPA 37.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements at time of original unit manufacture.
- K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify owner no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without owner's written permission.
 - 3. Downtime of emergency generator shall be minimized and coordinated with the Owner and local officials. A suitable source of emergency power must be available for the building during all occupied periods. Generator relocation and reconnection shall be planned for an unoccupied time of sufficient length or a temporary generator shall be provided by the Contractor.

1.9 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY

- A. Special Warranty: Contractor shall include general 1 year warranty for any new materials and all workmanship provided under this section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The existing generator being relocated is by Generac Power Systems, Inc. The unit is rated at 130 kW, 480 volt, 3-phase, has a 225 amp output breaker and 220 gallon base mounted diesel fuel tank.

2.2 ENGINE-GENERATOR SET

- A. Existing factory-assembled engine-generator set shall be relocated, installed and tested.
- B. Mounting Frame: Coordinate mounting requirements with new concrete pad. Note that pad will be oversized to accommodate a future larger unit.
- C. Generator-Set Performance:
 - 1. Start Time: Comply with NFPA 110, Type 10, system requirements, maximum 10 seconds.

2.3 REPLACEMENT PARTS

- A. All replacement parts shall be as recommended by Generac for the existing equipment and application.
- B. Block heater, 120 or 208/240 Volt AC. Thermostatically controlled and sized to maintain engine coolant at 90°F (32°C) to meet the start-up requirements of NFPA-99 and NFPA-110, Level 1.
- C. 12-volt batteries (2) capable of delivering the manufacturer's recommended minimum cold-cranking Amps required at 0°F.

2.4 CONTROL AND MONITORING

- A. Existing unit-mounted controller shall remain. Contractor shall be responsible for installation of new control and monitoring wiring from new transfer switch to unit and for relocation of existing remote annunciator.
- B. Existing Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.
 - 6. Engine lubricating-oil pressure gage.
 - 7. Running-time meter.
 - 8. Ammeter-voltmeter, phase-selector switch(es).
 - 9. Generator-voltage adjusting rheostat.
 - 10. Fuel tank derangement alarm.
 - 11. Fuel tank high-level shutdown of fuel supply alarm.
 - 12. Generator overload.
 - 13. Low coolant level.
- C. Remote Emergency-Stop Switch: Surface; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation. Contractor shall provide new switch and wiring to relocated generator controls.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 RELOCATION & INSTALLATION

- A. Relocate existing generator to new location as shown on the plans
 - 1. Remove any fuel remaining in existing fuel tank before transporting.
 - 2. Engage an independent laboratory or testing agency to analyze fuel content and certify that it is useable.
 - a. If fuel is acceptable, refill tank with existing fuel, and provide any additional new fuel to fill the tank
 - b. If fuel is unacceptable, dispose of fuel using a qualified fuel disposal service, and provide a full tank of new fuel. Provide written certification of proper disposal.
 - 3. Provide written test results prior to refilling tank with existing fuel.
- B. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 37 & 110.
- C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- E. Concrete Pad: Supply new concrete pad in accordance with manufacturers requirements and details on civil drawings. Pad stub up area shall be field coordinated to match generator stub up area. Pad shall accommodate an additional 12 inches of clearance on all sides of generator base.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Ground equipment according to Division 26 Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform the following checks and replacements for a Level II preventative maintenance service after unit relocation and connection but prior to performing tests listed below.
 - 1. Replace spark plugs.
 - 2. Replace ignition points and condensor (if applicable).
 - 3. Replace engine lubricating oil and filter.
 - 4. Check radiator/cooling system.
 - 5. Replace fuel filter.
 - 6. Check air cleaner and crankcase breather. Replace if required.
 - 7. Check warning lights. Replace if required.
 - 8. Check distributor/magneto. Adjust if required. Replace cap.
 - 9. Check engine battery charging generator/alternator.
 - 10. Check starter operation.
 - 11. Check and lubricate governor. Adjust if required.
 - 12. Check exhaust system.
 - 13. Check battery charger. Adjust if necessary.
 - 14. Check external wires for wear and tension.
 - 15. Check rotor bearings.
 - 16. Check solid state circuits, rotating diodes and rectifiers.
 - 17. Check F/R activator, rotating optic, stationary LED or rectifiers.
 - 18. Clean static exciter, collector rings and communicator.
 - 19. Check safety shutdowns.
 - 20. Check instruments and calibrate as needed.
 - 21. Replace starting batteries.
 - 22. Replace block heater.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switches and run them concurrently.
- F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and retest as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 263213

SECTION 263600 - TRANSFER SWITCHES

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 transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer and testing agency.
- B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." 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 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 test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.
- 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, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
 - 1. Notify owner no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without owner's written permission.

1.8 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contactor Transfer Switches:
 - a. Generac Power Systems, Inc.
 - b. Emerson; ASCO Power Technologies, LP.
 - c. GE Zenith Controls.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- H. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- J. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- K. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- L. Enclosures: General-purpose NEMA 250, Type 1 complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

- D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- J. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - 5. Test Switch: Simulate normal-source failure.
 - 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 - 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

- C. Identify components according to Division 26 Section "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- 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 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

- a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
- a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:

- 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
- 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
- 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

SECTION 264313 - TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Sections:
 - 1. Division 26 Section "Switchboards" for factory-installed TVSS.
 - 2. Division 26 Section "Panelboards" for factory-installed TVSS.
 - 3. Division 26 Section "Wiring Devices" for devices with integral TVSS.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed voltage rating.
- C. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
- B. Qualification Data: For qualified testing agency.
- C. Product Certificates: For TVSS devices, from manufacturer.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For TVSS devices to include in emergency, operation, and maintenance manuals.
- F. Warranties: Sample of special warranties.

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1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
- C. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
- D. Comply with NEMA LS 1.
- E. Comply with UL 1283 and UL 1449.
- F. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Architect and Construction Manager no fewer than two days in advance of proposed electrical service interruptions.
 - 2. Do not proceed with interruption of electrical service without Architect and Construction Manager written permission.
- B. Service Conditions: Rate TVSS 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: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, noncondensing.
 - 4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.7 COORDINATION

- A. Coordinate location of field-mounted TVSS devices to allow adequate clearances for maintenance.
- B. Coordinate TVSS devices with Division 26 Section "Electrical Power Monitoring and Control."

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
- B. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.9 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. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE SUPPRESSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings or comparable product by one of the following:
 - 1. ABB USA.
 - 2. AC Data Solutions.
 - 3. Advanced Protection Technologies Inc. (APT).
 - 4. Atlantic Scientific.
 - 5. Current Technology Inc.; Danaher Power Solutions.
 - 6. Danaher Power Solutions; United Power Products.
 - 7. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 8. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 9. Intermatic, Inc.
 - 10. LEA International.
 - 11. Leviton Mfg. Company Inc.
 - 12. Liebert Corporation; a division of Emerson Network Power.
 - 13. Northern Technologies, Inc.; a division of Emerson Network Power.
 - 14. Siemens Energy & Automation, Inc.
 - 15. Square D; a brand of Schneider Electric.
 - 16. Surge Suppression Incorporated.
- C. Surge Protection Devices:

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

1. Non-modular.
 2. LED indicator lights for power and protection status.
 3. Audible alarm, with silencing switch, to indicate when protection has failed.
 4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- D. Surge Protection Devices:
1. Comply with UL 1449.
 2. Modular design (with field-replaceable modules).
 3. Fuses, rated at 200-kA interrupting capacity.
 4. Fabrication using bolted compression lugs for internal wiring.
 5. Integral disconnect switch.
 6. Redundant suppression circuits.
 7. Redundant replaceable modules.
 8. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 10. LED indicator lights for power and protection status.
 11. Audible alarm, with silencing switch, to indicate when protection has failed.
 12. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 13. Six-digit transient-event counter set to totalize transient surges.
- E. Peak Single-Impulse Surge Current Rating: 320 kA per mode/640 kA per phase.
- F. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
1. Line to Neutral: 70,000 A.
 2. Line to Ground: 70,000 A.
 3. Neutral to Ground: 50,000 A.
- G. Protection modes and UL 1449 SVR for grounded wye circuits with 400 V for 208Y/120 V., 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120 V.
 2. Line to Ground: 400 V for 208Y/120 V.
 3. Neutral to Ground: 400 V for 208Y/120 V.
- H. Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 400 V.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

- I. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
 - 1. Line to Neutral: 400 V, 800 V from high leg.
 - 2. Line to Ground: 400 V.
 - 3. Neutral to Ground: 400 V.

- J. Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:
 - 1. Line to Line: 1000 V for 240 V.
 - 2. Line to Ground: 1000 V for 240 V.

2.2 PANELBOARD SUPPRESSORS

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

- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. ABB USA.
 - 2. AC Data Solutions.
 - 3. Advanced Protection Technologies Inc. (APT).
 - 4. Atlantic Scientific.
 - 5. Current Technology Inc.; Danaher Power Solutions.
 - 6. Danaher Power Solutions; United Power Products.
 - 7. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 8. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 9. Intermatic, Inc.
 - 10. LEA International.
 - 11. Leviton Mfg. Company Inc.
 - 12. Liebert Corporation; a division of Emerson Network Power.
 - 13. Northern Technologies, Inc.; a division of Emerson Network Power.
 - 14. Siemens Energy & Automation, Inc.
 - 15. Square D; a brand of Schneider Electric.
 - 16. Surge Suppression Incorporated.

- C. Surge Protection Devices:
 - 1. Non-modular.
 - 2. LED indicator lights for power and protection status.
 - 3. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

- D. Surge Protection Devices:

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

1. Comply with UL 1449.
 2. Modular design (with field-replaceable modules).
 3. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
 4. Fuses, rated at 200-kA interrupting capacity.
 5. Fabrication using bolted compression lugs for internal wiring.
 6. Integral disconnect switch.
 7. Redundant suppression circuits.
 8. Redundant replaceable modules.
 9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 10. LED indicator lights for power and protection status.
 11. Audible alarm, with silencing switch, to indicate when protection has failed.
 12. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 13. [Four] [Six]-digit transient-event counter set to totalize transient surges.
- E. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
- F. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:
1. Line to Neutral: 70,000 A.
 2. Line to Ground: 70,000 > A.
 3. Neutral to Ground: 50,000 A.
- G. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120 V.
 2. Line to Ground: 400 V for 208Y/120 V.
 3. Neutral to Ground: 400 V for 208Y/120 V.
- H. Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
1. Line to Neutral: 400 V.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- I. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
1. Line to Neutral: 400 V, 800 V from high leg.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- J. Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

1. Line to Line: 1000 V for 240 V.
2. Line to Ground: 800 V for 240 V.

2.3 ENCLOSURES

- A. Indoor Enclosures: NEMA 250 Type 1].
- B. Outdoor Enclosures: NEMA 250 Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 1. Provide multiple, [30] [60] [100]-A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

- A. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
 1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- 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. 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.
 2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

3. Complete startup checks according to manufacturer's written instructions.

E. TVSS device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Do not energize or connect [service entrance equipment] [panelboards] [control terminals] [data terminals] to their sources until TVSS devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to maintain TVSS devices.

END OF SECTION 264313

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
 2. Emergency lighting equipment including listing and wiring information.
 3. Ballast, including BF.
 4. Energy-efficiency data.
 5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
 6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
 - b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom lighting fixtures. 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.
- C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule as requiring samples. Each Sample shall include the following:
1. Lamps and ballasts, installed.
 2. Cords and plugs.
 3. Pendant support system.
- D. Installation instructions.
- E. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Lighting 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.
 4. Ceiling-mounted projectors.
 5. Structural members to which suspension systems for lighting 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.
7. Perimeter moldings.
- F. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- H. Field quality-control reports.
- I. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
- J. Warranty: Sample of special warranty.

1.5 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, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.
- D. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- E. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections where requested.
- 1. Obtain Architect's approval of fixtures for mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: Ten (10) years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine (9) years.
 - 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven (7) years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six (6) years.

1.8 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: Ten (10) for every one hundred (100) of each type and rating installed. Furnish at least one (1) of each type.
 - 2. Plastic Diffusers and Lenses: One (1) for every one hundred (100) of each type and rating installed. Furnish at least one (1) of each type.
 - 3. Fluorescent-Fixture-Mounted, Emergency Battery Pack: One (1) for every twenty (20) emergency lighting unit.
 - 4. Ballasts: One (1) for every one hundred (100) of each type and rating installed. Furnish at least one (1) of each type.
 - 5. Globes and Guards: One (1) for every twenty (20) of each type and rating installed. Furnish at least one (1) of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

- D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- H. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: One hundred percent (100%) virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- I. 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 ballast characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
 - e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
 - f. CCT and CRI for all luminaires.
- J. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one (1) filter on each ballast indicated to require a filter.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. General Requirements for Electronic Ballasts:
 - 1. Comply with UL 935 and with ANSI C82.11.

2. Designed for type and quantity of lamps served.
 3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: Less than ten percent (10%).
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Operating Frequency: 42 kHz or higher.
 8. Lamp Current Crest Factor: 1.7 or less.
 9. BF: 0.88 or higher.
 10. Power Factor: 0.95 or higher.
 11. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one (1) or more lamps fail.
- B. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.
- C. Electronic Programmed-Start Ballasts for T5, T8, T5HO, T5, and T5HO Lamps: Comply with ANSI C82.11 and the following:
1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 2. Automatic lamp starting after lamp replacement.
- D. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
1. Ballast Manufacturer Certification: Indicated by label.
- E. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- F. Ballasts for Low-Temperature Environments:
1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 2. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
- G. Ballasts for Residential Applications: Fixtures designated as "Residential" may use low-power-factor electronic ballasts having a Class B sound rating and total harmonic distortion of approximately thirty percent (30%).
- H. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- I. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: One hundred to five percent (100 to 5%) of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to twenty percent (20%) of normal.

3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
4. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.

J. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: One hundred percent (100%) of rated lamp lumens.
 - b. Low-Level Operation: Thirty percent (30%) of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

K. Ballasts for Tri-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: One hundred percent (100%) of rated lamp lumens.
 - b. Low-Level Operation: Thirty and sixty percent (30 and 60%) of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific tri-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: Class A.
4. Total Harmonic Distortion Rating: Less than twenty percent (20%).
5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher unless otherwise indicated.
9. Power Factor: 0.95, except fixtures designated as "Residential" may use low-power-factor electronic ballasts or higher.
10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

2.5 BALLASTS FOR HID LAMPS

- A. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
1. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
 2. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
 3. Lamp end-of-life detection and shutdown circuit.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: Less than twenty percent (20%).
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Lamp Current Crest Factor: 1.5 or less.
 8. Power Factor: 0.90 or higher.
 9. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
 10. Protection: Class P thermal cutout.
 11. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - a. High-Level Operation: One hundred percent (100%) of rated lamp lumens.
 - b. Low-Level Operation: Thirty-five percent (35%) of rated lamp lumens.
 - c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
 12. Continuous Dimming Ballast: Dimming range shall be from one hundred to thirty-five percent (100 to 35%) of rated lamp lumens without flicker.
 - a. Ballast Input Watts: Reduced to a maximum of fifty percent (50%) of normal at lowest dimming setting.
- C. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter/starter shall have an average life in pulsing mode of ten thousand (10,000) hours at an igniter/starter-case temperature of 90 deg C.
1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.

2. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

2.6 QUARTZ LAMP LIGHTING CONTROLLER

- A. General Requirements for Controllers: Factory installed by lighting fixture manufacturer. Comply with UL 1598.
- B. Standby (Quartz Restrike): Automatically switches quartz lamp on when a HID lamp in the fixture is initially energized and during the HID lamp restrike period after brief power outages.
- C. Connections: Designed for a single branch -circuit connection.
- D. Switching Off: Automatically switches quartz lamp off when HID lamp strikes.
- E. Switching Off: Automatically switches quartz lamp off when HID lamp reaches approximately sixty percent (60%) light output.

2.7 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, chevrons, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: LEDs, fifty thousand (50,000) hours minimum rated lamp life.
 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack. (Sage Park Only)
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to eighty percent (80%) of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
 3. Exit Signs wired to emergency lighting power source (AC type): Shall be wired through a UL 924 listed relay providing connection to emergency lighting circuit with an alternate non-emergency circuit (normal lighting) to power the sign on a loss of the emergency circuit.

4. Master/Remote Sign Configurations:
 - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in battery for power connection to remote unit.
 - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

- C. Where scheduled as master/remote sign for floor proximity installation, signs shall meet all general exit sign requirements. In addition, floor proximity sign shall have the following features:
 1. Low profile wall mount housing furnished with polycarbonate shield.
 2. Normal and emergency power received from master unit.

- D. Specified Area of Refuge signs shall meet power and illumination requirements for exit signs. These shall be furnished with appropriate text and the universal symbol of accessibility (wheelchair symbol).

- E. Specified Signs for Accessible Exit shall meet power and illumination requirements for exit signs. These shall be furnished with universal symbol of accessibility (wheelchair symbol) having a minimum height of 6 inches.

- F. Refer to lighting fixture schedule on drawings for specification of the following features:
 1. Number of Faces: One (1) or two (2).
 2. Input voltage.
 3. Universal wheelchair symbol meeting the requirements of IBC 1011.1.2.

2.8 EMERGENCY LIGHTING UNITS (Sage Park Only)

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 1. Battery: Sealed, maintenance-free, lead-acid type.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to eighty percent (80%) of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 7. Integral Time-Delay Relay: Holds unit on for fixed interval of fifteen (15) minutes when power is restored after an outage.

8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is announced by an integral audible alarm and a flashing red LED.

2.9 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life twenty thousand (20,000) hours unless otherwise indicated.
- B. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500, and average rated life of twenty thousand (20,000) hours unless otherwise indicated.
- C. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000K and average rated life of twenty thousand (20,000) hours unless otherwise indicated.
- D. T5HO rapid-start, high-output lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of twenty thousand (20,000) hours unless otherwise indicated.
- E. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of ten thousand (10,000) hours at three (3) hours operation per start, and suitable for use with dimming ballasts unless otherwise indicated.
 1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
 2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
 3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
 4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
 5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
 6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
 7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.10 HID LAMPS

- A. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900 K, and average rated life of twenty-four thousand (24,000) hours, minimum.
 1. Dual-Arc Tube Lamps: Arranged so only one (1) of two (2) arc tubes is lighted at one (1) time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate eight to fifteen percent (8 to 15%) of normal light output.
- B. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and color temperature 4000 K.

- C. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.
- D. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.
- E. Low-Pressure Sodium Lamps: ANSI 78.41, CRI 0, and color temperature 1800 K.

2.11 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: ½-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two (2), ½-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.12 QUALITY ASSURANCE

- A. Manufacturer's products shall be listed by Underwrites Laboratories, Inc. (UL) and comply with the National Electrical Code (NEC).
- B. The dimming and control equipment specified herein shall be the coordinated product of a single manufacturer. All dimmer and cabinet fabrication must take place in the manufacturer's plant. The use of subcontracted component assemblers is not acceptable.
- C. The manufacturer shall be one who has been continuously engaged in the manufacture of theatrical lighting controls and dimmers for a minimum of ten (10) years.
- D. All equipment shall be one hundred percent (100%) tested as a complete system. Manufacturers using sample-testing methods are not acceptable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 2. Install lamps in each luminaire.
- 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. 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 from lighting fixture corners.
 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two (2) ¾-inch metal channels spanning and secured to ceiling tees.
 4. Install at least one (1) 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 three (3).
- E. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one (1) point and tubing or rod for suspension for each unit length of fixture chassis, including one (1) at each end.
 4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least one hundred (100) hours at full voltage.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

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. Exterior luminaires with lamps and ballasts.
- 2. Luminaire-mounted photoelectric relays.
- 3. Poles and accessories.
- 4. Luminaire lowering devices.

B. Related Sections:

- 1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. HID: High-intensity discharge.
- D. LER: Luminaire efficacy rating.
- E. Luminaire: Complete lighting fixture, including ballast housing if provided.
- F. Pole: Luminaire support structure, including tower used for large area illumination.
- G. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.

- C. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.
- D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
 - 1. Basic wind speed for calculating wind load for poles exceeding 49.2 feet (15 m) in height is 100 mph (45 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 50 years.
 - c. Velocity Conversion Factors: 1.0.
 - 2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 50 years.
 - c. Velocity Conversion Factors: 1.0.

1.5 SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
 - 2. Details of attaching luminaires and accessories.
 - 3. Details of installation and construction.
 - 4. Luminaire materials.
 - 5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
 - b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 6. Photoelectric relays.
 - 7. Ballasts, including energy-efficiency data.
 - 8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
 - 9. Materials, dimensions, and finishes of poles.
 - 10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
 - 11. Anchor bolts for poles.
 - 12. Manufactured pole foundations.
- 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. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
 4. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.
- D. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.
- E. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- F. Field quality-control reports.
- G. Operation and Maintenance Data: For luminaires and poles include in emergency, operation, and maintenance manuals.
- H. Warranty: Sample of special warranty.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. 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.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Comply with NFPA 70. DELIVERY, STORAGE, AND HANDLING
- F. Package aluminum poles for shipping according to ASTM B 660.
- G. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- H. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.

- I. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- J. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.8 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: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
 2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
 3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
- B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- G. Exposed Hardware Material: Stainless steel.
- H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
- K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if

- present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.
 - b. Color: Match Architect's sample of manufacturer's standard color.
 - c. Color: As selected by Architect from manufacturer's full range.
- N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: Dark bronze.
- O. 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 ballast characteristics:
 - a. "USES ONLY" and include specific lamp type.
 - b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
 - e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
 - f. CCT and CRI for all luminaires.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-

second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.4 FLUORESCENT BALLASTS AND LAMPS

A. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.

B. Ballast Characteristics:

1. Power Factor: 90 percent, minimum.
2. Sound Rating: Class A.
3. Total Harmonic Distortion Rating: Less than 10]percent.
4. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
5. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
6. Transient-Voltage Protection: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F (minus 18 deg C) and higher.

2.5 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).
3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - a. Restrike Range: 105- to 130-V ac.
 - b. Maximum Voltage: 250-V peak or 150-V ac rms.
2. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

2.6 HID LAMPS

- A. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), CCT color temperature 1900 and average rated life of 24,000 hours, minimum.
 1. Dual-Arc Tube Lamp: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
- B. Low-Pressure Sodium Lamps: ANSI C78.43.
- C. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and CCT color temperature 4000 K.
- D. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and CCT color temperature 4000 K.
- E. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and CCT color temperature 4000 K.

2.7 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 1. Materials: Shall not cause galvanic action at contact points.
 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
 3. Anchor-Bolt Template: Plywood or steel.

- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws. Provide on all, except wood poles.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.8 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 - 1. Shape: Round, tapered, Round, straight, Square, tapered, Square, straight.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Single-arm, Truss, Davit type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless an/or galvanize-steel bolts.
 - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- G. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- K. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
 - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected by Architect/Engineer from manufacturer's full range.

2.9 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: Round, tapered, Round, straight, Square, tapered, Square, straight.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.

2. Finish: Same as pole.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: As selected by Architect/Engineer from manufacturer's full range.

2.10 FIBERGLASS POLES

- A. Poles: Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole. Not less than 65 percent fiberglass, with resin and pigment making up the remainder.
1. Resin Color: Dark bronze; provide uniform coloration throughout entire wall thickness.
 2. Surface Finish: Pigmented polyurethane, with a minimum dry film thickness of 1.5 mils (0.04 mm). Polyurethane may be omitted if the surface layer of pole is inherently UV inhibited.

2.11 DECORATIVE POLES

- A. Pole Material:
1. Cast ductile iron.
 2. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
 3. Cast aluminum.
 4. Cast concrete.
 5. Spun concrete.
 6. Steel tube, covered with closed-cell polyurethane foam, with a polyethylene exterior.
- B. Mounting Provisions:
1. Bolted to concrete foundation.
 2. Embedded.
- C. Fixture Brackets:

1. Cast ductile iron.
2. Cast gray iron.
3. Cast aluminum.

2.12 PRESTRESSED CONCRETE POLES

2.13 POLE ACCESSORIES

- A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
 1. Recessed, 12 inches (300 mm) above finished grade.
 2. Nonmetallic polycarbonate plastic or reinforced fiberglass, Type 4X enclosure.
 3. With cord opening.
 4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept indicated accessories.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 3. Trees: [15 feet (5 m)] from tree trunk.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 3. Install base covers unless otherwise indicated.
 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
1. Dig holes large enough to permit use of tampers in the full depth of hole.
 2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
 2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
 3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
 4. Cure concrete a minimum of 72 hours before performing work on pole.
- G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
- H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.

- B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
 - a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
 - b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
 - c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
 - d. IESNA LM-64, "Photometric Measurements of Parking Areas."
 - e. IESNA LM-72, "Directional Positioning of Photometric Data."
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

END OF SECTION 265600

SECTION 270528 - PATHWAYS 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.
- B. Related Drawings
 - 1. "T" Technology Plans

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Metal wireways and auxiliary gutters.
 - 5. Nonmetallic wireways and auxiliary gutters.
 - 6. Surface pathways.
 - 7. Boxes, enclosures, and cabinets.
 - 8. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
 - 2. Section 280528 "Pathways for Security Systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal 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 certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Alpha Wire Company.
4. Anamet Electrical, Inc.

5. Electri-Flex Company.
 6. O-Z/Gedney; a brand of EGS Electrical Group.
 7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.
 8. Republic Conduit.
 9. Robroy Industries.
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company; a division of John Maneely Company.
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Arnco Corporation.
 - 5. CANTEX Inc.
 - 6. CertainTeed Corp.
 - 7. Condux International, Inc.
 - 8. Electri-Flex Company.
 - 9. Kraloy.
 - 10. Lamson & Sessions; Carlon Electrical Products.
 - 11. Niedax-Kleinhuis USA, Inc.
 - 12. RACO; a Hubbell company.
 - 13. Thomas & Betts Corporation.

- B. General Requirements for Nonmetallic Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.

- C. RNC: Type EPC-40-PVC complying with NEMA TC 2 and UL 651 unless otherwise indicated.

- D. Rigid HDPE: Comply with UL 651A.

- E. Continuous HDPE: Comply with UL 651B.

- F. RTRC: Comply with UL 1684A and NEMA TC 14.

- G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

- H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Alpha Wire Company.
 - 2. Arnco Corporation.
 - 3. Endot Industries Inc.

4. IPEX.
5. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

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. Cooper B-Line, Inc.
2. Hoffman; a Pentair company.
3. Mono-Systems, Inc.
4. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250 and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

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. Allied Moulded Products, Inc.
2. Hoffman; a Pentair company.
3. Lamson & Sessions; Carlon Electrical Products.
4. Niedax-Kleinhuis USA, Inc.

B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

- C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SURFACE PATHWAYS

- A. General Requirements for Surface Pathways:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mono-Systems, Inc.
 - b. Niedax-Kleinhuis USA, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.
- C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems Division.
 - b. Lamson & Sessions; Carlon Electrical Products.
 - c. Mono-Systems, Inc.

- d. Panduit Corp.
- e. Wiremold / Legrand.

2.7 BOXES, ENCLOSURES, AND CABINETS

- 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. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. Hoffman; a Pentair company.
 - 6. Hubbell Incorporated; Killark Division.
 - 7. Lamson & Sessions; Carlon Electrical Products.
 - 8. Milbank Manufacturing Co.
 - 9. Molex; Woodhead Brand.
 - 10. Mono-Systems, Inc.
 - 11. O-Z/Gedney; a brand of EGS Electrical Group.
 - 12. RACO; a Hubbell company.
 - 13. Robroy Industries.
 - 14. Spring City Electrical Manufacturing Company.
 - 15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
 - 16. Thomas & Betts Corporation.
 - 17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-B.
 - 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- F. Metal Floor Boxes:
 - 1. Material: Cast metal
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- J. Device Box Dimensions: as specified within the architectural drawings.
- K. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, with continuous-hinge cover with flush latch unless otherwise indicated.
 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures:
 - a. Material: Plastic.
 - b. Finished inside with radio-frequency-resistant paint.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Damp or Wet Locations: GRC.
 6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
 7. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
 8. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.

- C. Pathway Fittings: Compatible with pathways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. EMT: Use setscrew or compression, cast-metal fittings. Comply with NEMA FB 2.10.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface pathways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

- 5. Change from ENT to RNC, Type EPC-40-PVC before rising above floor.

- J. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

- P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.

- R. Surface Pathways:
 - 1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
 - 2. Install surface pathway with a minimum 2-inch radius control at bend points.
 - 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

- T. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.
- U. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service pathway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- W. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.
- DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270536 - CABLE TRAYS 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.
- B. Related Drawings
 - 1. "T" Technology Plans

1.2 SUMMARY

- A. Section Includes:
 - 1. Ladder cable trays.
 - 2. Wire-basket cable trays.
 - 3. Single-rail cable trays.
- B. Related Requirements:
 - 1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

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.
 - 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. Component Importance Factor: 1.5.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - 1. Temperature Change: 120 deg F

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 LADDER CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Chatsworth
 - 3. Wiremaid Products Division; Vutec Corporation.
- C. Description:
 - 1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
 - 2. Rung Spacing: 12 inches o.c.
 - 3. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
 - 4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
 - 5. No portion of the rungs shall protrude below the bottom plane of side rails.
 - 6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - 7. Minimum Usable Load Depth: 6 inches.
 - 8. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
 - 9. Width: 12 inches unless otherwise indicated on Drawings.
 - 10. Fitting Minimum Radius: 12 inches .
 - 11. Class Designation: Comply with NEMA VE 1.
 - 12. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - 13. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.
 - 14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.4 WIRE-BASKET CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product of one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Chatsworth
 - 3. Snake-tray.
 - 4. Wiremaid Products Division; Vutec Corporation.
- C. Description:
 - 1. Configuration: Wires are formed into a standard 2-by-4-inch wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
 - 2. Materials: High-strength-steel longitudinal wires with no bends.
 - 3. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.
 - 4. Sizes:
 - a. Straight sections shall be furnished in standard 118-inch lengths.
 - b. Wire-Basket Depth: 12 inches wide.
 - c. Wire-Basket Depth: 4 wide or as required.
 - 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.

2.5 SINGLE-RAIL CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Chatsworth
 - 3. Wiremaid Products Division; Vutec Corporation.
- C. Description:
 - 1. Configuration: Center rail with extruded-aluminum rungs arranged symmetrically about the center rail.

2. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
3. Rung Spacing: 12 inches o.c.
4. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
5. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
6. Width: 12 inches unless otherwise indicated on Drawings.
7. Support Point: Splice fittings shall be hanger support point.
8. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
9. Loading Depth: 4 inches
10. Maximum Loads: 50 lb/ft.
11. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.
15. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.

2.6 MATERIALS AND FINISHES

A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1008/A 1008M, Grade 33, Type 2.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Mill galvanized before fabrication.
 - a. Standard: Comply with ASTM A 653/A 653M, G90.
 - b. Hardware: Galvanized, ASTM B 633.
5. Finish: Electrogalvanized before fabrication.
 - a. Standard: Comply with ASTM B 633.
 - b. Hardware: Galvanized, ASTM B 633.
6. Finish: Hot-dip galvanized after fabrication.
 - a. Standard: Comply with ASTM A 123/A 123M, Class B2.
 - b. Hardware: Chromium-zinc plated, ASTM F 1136.
7. Finish: [poxy-resin or Powder-coat enamel paint].
 - a. Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b. Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.

- c. Epoxy-Resin Topcoat: Epoxy, cold-cured, gloss, MPI# 77.
 - d. Hardware: Chromium-zinc plated, ASTM F 1136.
- 8. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
 - 9. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.
- B. Aluminum:
- 1. Materials: Alloy 6063-T6 according to ANSI H 35.1/H 35.1M for extruded components and Alloy 5052-H32] or Alloy 6061-T6 according to ANSI H 35.1/H 35.1M for fabricated parts.
 - 2. Hardware: Chromium-zinc-plated steel, ASTM F 1136.
 - 3. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
- C. Stainless Steel:
- 1. Materials: Low-carbon, passivated, stainless steel, Type 304L or Type 316L, ASTM F 593 and ASTM F 594.
 - 2. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.7 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Covers: Ventilated-hat type made of same materials and with same finishes as cable tray.
- C. Barrier Strips: Same materials and finishes as for cable tray.
- D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.8 WARNING SIGNS

- A. Lettering: 1-1/2-inch 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."

2.9 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA FG 1.
- 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.
- G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."
- H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- 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. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- L. Locate and install supports according to NEMA FG 1. Do not install more than one cable tray splice between supports.
- M. Support wire-basket cable trays with center support hangers or trapeze hangers or wall brackets.
- N. Support center support hangers or trapeze hangers for wire-basket trays with 1/4-inch diameter rods.
- O. 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.
- P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.

- Q. Make changes in direction and elevation using manufacturer's recommended fittings.
- R. Make cable tray connections using manufacturer's recommended fittings.
- S. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
- T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- U. Install cable trays with enough workspace to permit access for installing cables.
- V. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- W. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
- X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- Y. 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 260526 "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. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- D. 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.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

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.
- 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.
- E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.
- F. In existing construction, remove inactive or dead cables from 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 and NEMA FG 1.

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, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
 - 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 retorqued 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 270536

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Drawings
 - 1. "T" Technology Plans
- C. Related Sections:
 - 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.

1.3 ACTION SUBMITTALS

- A. Data: For each type of product.
- B. LEED Submittals:
 - 1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products 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."

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board
- C. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized-steel sheet.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - 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.
 - e. Proco Products, Inc.
 - 2. Sealing Elements: EPDM or equivalent rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Carbon steel.
 - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

- C. Design Mix: 5000-psi, 28-day compressive strength. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 271544

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Division 01 Section 019113 General Commissioning Requirements.
- C. Related Drawings
 - 1. "T" Technology Plans
- D. Related Sections:
 - 1. Division 271300 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
 - 2. Division 271500 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.2 SUMMARY

- A. Description
 - 1. The scope of work required as part of this project shall include (1) one Main Equipment Room (MER) room #B205 and (4) four Telecommunication Rooms (TR) #E209, F213, C102 & G204. These areas shall include floor mounted 2-post racks, server cabinets, ladder racking and wall mounted devices as indicated within the drawing details.
- B. Section Includes:
 - 1. Telecommunications Mounting Devices.
 - 2. Backer boards.
 - 3. Telecommunications Equipment racks and cabinets.
 - 4. Telecommunications service entrance pathways.
 - 5. Grounding and bonding.

1.3 DEFINITIONS

- A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- B. BICSI: Building Industry Consulting Service International.

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

- C. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
- D. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- E. LAN: Local Area Network.
- F. RCDD: Registered Communications Distribution Designer.
- G. Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
- H. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- I. "Project Manager" shall mean the Owner's appointed representative.
- J. "As Necessary" shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.
- K. "As Required" shall mean work which is required for completed construction and is shown on the drawings or described in the project specification.
- L. "Install" shall mean to set in place complete with all mounting facilities and connections as required ready for normal use of service.
- M. "Substantial Completion" shall mean that the project is sufficiently complete to be utilized for its intended use as stated in the body of this written specification.
- N. "Conduit" shall include all fittings, sleeves, connections, hangers and other accessories related to such conduit.
- O. "Surface Metal Raceway" shall include all fittings, sleeves, connections, hangers and other accessories related to such raceway.
- P. "Concealed" shall mean hidden from sight, as in chases, furred spaces, shafts, fixed ceiling or embedded in construction.
- Q. "Exposed", shall mean not "concealed" as defined above.
- R. "Governmental" shall mean all municipal, state and federal government agencies.
- S. The words "Furnish", "Supply" and "Provide" shall mean purchase, deliver to the job site, protect and provide interim storage and install in accordance with manufacturer's specifications.
- T. Words "Approved Equal" shall mean any product which in the opinion of the Technology Consultant is equal in quality, arrangement, appearance, and performance to the product specified.

- U. "Cabling" shall mean cable assembly, raceway, conductors, fittings and any other necessary accessories to make a complete wiring system.
- V. "Product" shall mean any item of equipment, material, fixture, apparatus, appliance or accessory installed under this Division.
- W. Words in the singular shall also mean and include the plural, wherever the context so indicates, and words in the plural shall mean the singular, wherever the context so indicates.
- X. "Contractor" refers to the bidding/installation Contractor responsible for furnishing and installation of all work indicated within this specification.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Floor-mounted equipment racks and cabinets and cable pathways 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."

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: As-built 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.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- D. Seismic Qualification Certificates: For floor-mounted racks, cabinets, 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. 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. Installation of products shall be performed in accordance with the Manufacturer's suggested Installation procedures.
- B. 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/NTS and/or Commercial Installer, Level 2.
 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician and/or 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 and/or Commercial Installer, Level 2 to perform the on-site inspection.
- C. Telecommunications Pathways and Spaces shall comply with TIA/EIA-569-A.
- D. Grounding shall comply with ANSI-J-STD-607-A.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install equipment racks, cabinets, frames or cable trays until spaces are enclosed, built-out and weather-tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.8 COORDINATION

- A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier/ Service Providers.
 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 2. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of the Voice equipment, LAN equipment, Security Equipment, PA and Master Clock equipment and all other systems that share space within the Telecommunication Equipment rooms.
- B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.1 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.
- B. Cable Support: Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
 - 1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
 - 2. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 3. Lacing bars, spools, J-hooks, and D-rings.
 - 4. Straps and other devices.
- C. Conduit and Boxes: are not within part of this section and shall be described within other sections of this bid document.

2.2 BACKBOARDS

- A. Backboards shall be furnished and installed as part of this specification and located on a minimum of 3 walls of the MER and TR rooms.
- B. Backboard sizes: 3/4 by 48 by 96 inches.
- C. Plywood shall be fire-retardant treated with (2) coats of black fire retardant paint.
- D. Plywood shall comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.3 EQUIPMENT FRAMES

- A. The desired products are specified within the drawing documents. If an alternate is submitted, the alternate must conform with all characteristics of the specified product that is within the drawing documents.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
 - 1. Great Lakes
 - 2. Chatsworth Products, Inc
 - 3. Middle Atlantic
- C. General Frame Requirements:
 - 1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Module Dimension: Width compatible with EIA 310 standard, 19-inch panel mounting.

3. Finish: Manufacturer's standard, baked-polyester powder coat.
- D. 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.
- E. Cable Management for Equipment Frames:
 1. Metal, with integral wire retaining fingers.
 2. Baked-polyester powder coat finish.
 3. Vertical cable management panels shall have front and rear channels, with covers.
 4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

PART 3 - EXECUTION

3.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

3.2 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.
- B. Install underground pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.

3.3 Install underground entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems "INSTALLATION".

- A. Comply with NECA 1.
- B. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- 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.

3.4 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- B. All conduits etc., passing through fire rated floors, walls and partitions, shall have the space between the raceways, sleeves and all penetrations filled with a reusable fire stopping material

such as Firestop Putty, Adhesive Firestop Sealant or Firestop Compound as manufactured by STI or approved equal.

3.5 GROUNDING

- A. Comply with ANSI-J-STD-607-A.
- B. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
 - 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. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2, Class 3, or Class 4 level of administration including optional identification requirements of this standard.
- C. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 271300 - COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Drawings:
 - 1. "T" Technology Plans
- C. Related Sections:
 - 1. Division 271100 Section "Communications Equipment Room Fittings".

1.2 SUMMARY

- A. Description
 - 1. This project shall be as phased approach as specified within the phasing section of this bid manual. The scope of work required as part of this project shall include a temporary service feed from the existing telecommunication distribution rooms to the new telecommunication rooms. This temporary cabling shall be replaced with a permanent cabling during the phased renovations of the High School.
 - 2. This temporary feed shall include the following:
 - a. Fiber optic cabling between the existing telecommunication rooms and all new spaces so that no occupied classroom shall be without data connectivity to the existing LAN.
 - b. Copper cabling between the existing PBX and telephone service provider demarc and all new spaces so that no occupied section of this facility shall be without voice connectivity to the existing PBX.
 - c. After renovation to each section, the permanent cabling shall be utilized for all above connectivity. This new cabling is specified within the bid documents.
- B. Section Includes:
 - 1. Pathways.
 - 2. UTP cable.
 - 3. Multi mode: OM3, 50/125 micrometer, 24 strand optical fiber cabling.
 - 4. Cable connecting hardware, patch panels, and cross-connects.
 - 5. Cabling identification products.
 - 6. Testing procedures.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.

- 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 Tele-communications equipment rooms, main terminal spaces and entrance facility rooms for the voice/data cabling systems.
- B. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patching or jumpers used for backbone-to-backbone cross-connection to service provider equipment.
- C. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 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 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
- B. Shop Drawings:
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration drawings and printouts.

4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 5. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to side of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Maintenance Data: For splices and connectors to include in maintenance manuals.
- G. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
1. Layout Responsibility: Preparation of Shop Drawings and field testing program development by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. 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: 50 or less.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- F. Grounding: Comply with ANSI-J-STD-607-A.

1.8 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.

1.9 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.

1.10 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 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. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 UTP CABLE

- A. Description: Voice Backbone Cabling.
- B. Cable shall be 100-ohm, 100 -pair UTP, formed into 25-pair binder groups, plenum rated cable.
 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 5E.
- C. 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. Belden
 2. Mohawk/CDT
 3. Berk-Tek

2.3 UTP CABLE HARDWARE

- 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. Ortronics
 2. Hubbell Premise Wiring
 3. Leviton
- 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. Connecting Blocks: 110-style IDC for Category 5E. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- D. 100 Pair 110 Style CAT 5E 19” rack mounted patch panels to allow for cross-connection from voice origination (PBX) to workstations via CAT 5E patch cords.
- E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
- F. 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, plus spares and blank positions adequate to suit specified expansion criteria.

- G. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

2.4 OPTICAL FIBER CABLE

- A. Description: Data Backbone Cabling.
- 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. Berk-Tek
 - 2. Belden
 - 3. Mohawk
 - 4. Corning
- C. Description: Multimode, OM3, 50/125, 12-fiber, nonconductive, tight buffer, armored optical, plenum rated, fiber cable.
 - 1. Comply with ICEA S-83-596 for mechanical properties.
 - 2. Comply with EIA/TIA-568-B.3 for performance specifications.
 - 3. Comply with EIA/TIA-492AAAD for detailed specifications.
 - 4. Maximum Attenuation, Conform to EIA/TIA-455-61: 2.50 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
 - 5. Minimum Modal Bandwidth, Conform to EIA/TIA-455-204: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- D. Jacket:
 - 1. Jacket Color: Orange.
 - 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.

2.5 OPTICAL FIBER CABLE HARDWARE

- 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. Berk-Tek
 - 2. Hubble
 - 3. Corning
 - 4. Leviton
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 - 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type LC connectors. Insertion loss not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.6 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.
- B. Labeling of all cable is described within the drawing documents.

2.7 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. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
- E. Cable will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

- A. Wiring Method: Install cables in raceways and J-hooks except where cable trays are required in Drawings. 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 Division 26 Section "Raceway and Boxes for Electrical Systems."

- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. 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.

3.3 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.
- B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
- C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- E. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- F. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard when entering room from overhead.
 - 4. Extend conduits 3 inches above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.4 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA/EIA-568-B.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 10. In the communications equipment room, install a 10-foot long service loop on each end of cable.
 11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.2.
 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:
1. Comply with TIA/EIA-568-B.3.
 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 above ceilings by cable supports not more than 60 inches apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- F. 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.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

- a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
- a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- B. 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 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 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.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 1. Administration Class: 2.
 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

- B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- C. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA/EIA standard as it applies to this Section. 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 Division 27 Section "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, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- G. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- 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.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/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) Multimode backbone link measurements: Test at 850 and 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - a) 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.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 271300

SECTION 27 15 00 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Drawings
 - 1. "T" Technology Plans
- C. Related Sections:
 - 1. Division 271300 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
 - 2. Division 271100 Section "Communications Equipment Room Fittings".

1.2 SUMMARY

- A. Section Includes:
 - 1. Pathways.
 - 2. UTP cabling.
 - 3. Cable connecting hardware, patch panels, and cross-connects.
 - 4. Telecommunications outlet/connectors.
 - 5. Cabling system identification products.
 - 6. Cable management system.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.
- C. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- D. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- E. EMI: Electromagnetic interference.
- F. IDC: Insulation displacement connector.

- G. Ladder Rack / Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- H. LAN: Local area network.
- I. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- J. RCDD: Registered Communications Distribution Designer.
- K. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.
- L. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.
- M. UTP: Unshielded twisted pair.

1.4 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 "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, unless otherwise specified within the drawing documents.
 - 2. Horizontal cabling shall contain no transition points or consolidation points between the horizontal cross-connect and the telecommunications outlet/connector.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
 - 4. Splitters shall not be installed as part of the horizontal cabling.
- B. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.
- C. If the installation contractor believes that any cabling will exceed the 295 feet, they are to make the technology consultant aware of this prior to installing the cable so that a remedy can be put in place. All cabling that is installed and exceeds the 295 feet, may be subject to be removed at the installation contractor's expense to attain a length less than 295 feet.

1.5 PERFORMANCE 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.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.

- B. Shop Drawings:
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration drawings and printouts.
 - 4. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 - 5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 - 6. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to side of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

- D. Source quality-control reports.

- E. Field quality-control reports.

- F. Maintenance Data: For splices and connectors to include in maintenance manuals.

- G. 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.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. 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: 50 or less.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- F. Grounding: Comply with ANSI-J-STD-607-A.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical loss test set.
 - 2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
 - 3. Test each pair of UTP cable for open and short circuits.

1.9 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.

1.10 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and 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.

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. Ladder Rack / Cable Tray:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ortronics
 - b. Cooper B-Line, Inc.
 - c. Chatsworth Products
 - d. Snake Tray
 - 2. Ladder Rack Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch thick.
 - a. Ladder Rack Trays: Nominally 12 inches wide, and a rung spacing of 12 inches.
 - b. Must be supported every 10' minimally.
- D. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."
 - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 UTP CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berk-Tek
 - 2. Mohawk; a division of Belden CDT.

3. Belden
4. General

B. Description: 100-ohm, 4-pair UTP, formed into 4-pair, binder groups covered with a blue plenum rated 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 6.

2.3 UTP CABLE HARDWARE

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

1. Ortronics
2. Leviton Voice & Data Division.
3. Hubbell Premise Wiring.

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. Connecting Blocks: 110-style IDC for Category 5E. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable indicated, plus spares and blank positions adequate to suit specified expansion criteria.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

2.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1, category 6.

B. Workstation Outlets: Multi-port-connector assemblies mounted in single-gang faceplate.

1. Plastic Faceplate: As specified within the drawing documentation.
2. For use with snap-in jacks accommodating any combination of UTP work area cords.

3. Flush mounting jacks, positioning the cord at a 45-degree angle.
4. Legend: Machine printed, in the field, using adhesive-tape label.
5. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.5 GROUNDING

- A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with ANSI-J-STD-607-A.

2.6 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
- C. Labeling for all cabling and termination equipment is described within the drawing package.

2.7 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-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 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, and in gypsum board partitions where unenclosed wiring method may be used. Conceal 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 Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
- C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- E. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- F. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard when entering room from overhead.
 - 4. Extend conduits 3 inches above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA/EIA-568-B.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. MUTOA shall not be used as a cross-connect point.
 - 5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

- b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
- a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping."
- B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 IDENTIFICATION

- A. All labeling of workstation outlets and patch panels shall be described by the Owner prior to testing and labeling of these devices.
- B. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "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.
- C. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- D. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- E. 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.

- F. 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.
- G. 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.
- H. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 - 6. Labeling is described within drawing package.
- I. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
 - 1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for

- compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2 for category 6 systems. 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 workstation outlet. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2, category 6 standards:
 - 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/connectors are installed.
 - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271500

SECTION 274100 - AUDIO VIDEO SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Interactive Whiteboards and accessories
- B. Projectors and accessories
- C. Speakers and accessories
- D. A/V Controller
- E. A/V Cabling

1.2 RELATED DOCUMENTS

- A. Supplementary instructions to Bidders within Volume I, apply to this Section.
- B. Related Drawings:
 - 1. "T" Technology Plans

1.3 SUMMARY

- A. Interconnection from/to all devices and teachers station outlets, testing, all configurations and training are part of this section.
- B. All pre-existing smart boards shall be reused and relocated as part of this project.
- C. The contractor awarded this contract shall dismount, relocate and remount the existing smart boards to the new locations as indicated within the architectural drawings.
- D. All existing smart boards that do not have the projector as part of the board (Smart boards #SBX885ix) shall receive a new projector and projector mounting arm as described within the architectural drawings and this specification.
- E. All areas shall receive new cabling as specified.
- F. All supplemental locations shall receive new Smart boards, projectors and associated devices as specified within this bid package.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

- B. Shop Drawings: From approved manufacturer for each type of device required. Include plan view locations, elevations, installation details, and accessories.
 - 1. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
- C. Product Data: Submit manufacturer's technical data, product specifications, installation instructions, and other pertinent information as applicable for each product or material specified.
- D. Operating and Maintenance instructions for each product.
- E. Samples of Manufacturer's standard and extended Warranties.
- F. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation.
- G. Operation and Maintenance Data: For Interactive Whiteboards, Projectors and speakers.
 - 1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.5 QUALITY ASSURANCE

- A. Single Source Responsibility: Obtain all materials from one source from a single approved manufacturer for each different product required.
- B. Certification: CE, FCC Class A

1.6 DELIVERY, STORAGE AND HANDLING

- A. Take care in handling products in accordance with manufacturer's instructions.
- B. Store indoors in original undamaged packaging, in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity. Store products upright in secure, protected area. Do not stack! Verify with manufacturer that site conditions are acceptable before receiving material.
- C. 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 temperature-controlled 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.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of any device and equipment related to operation, and equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Unless stated otherwise within product descriptions, a [Two] 2 year warranty from date of Substantial Completion shall be provided.
 - 2. Provide information on available extended warranties.

PART 2 - PRODUCTS

2.1 INTERACTIVE WHITEBOARD W/PROJECTOR

- A. The selected manufacturer shall be **SMART** Series Interactive Whiteboards, Canada. Other manufacturers will not be considered, the district has standardized on this manufacturer.
- B. The selected model shall be:
 - 1. **SMART model #SBX885**, wall mounted, Overall size 78.5” wide x 53.375” high x 6.5” deep with writing surface of 74” wide x 46.25” high, weighing 60 lbs.
- C. Optional Accessories shall include: Bluetooth connection module to PC.

2.2 PROJECTORS

- A. This device shall be used with the interactive whiteboard.
- B. The selected manufacturer shall be EPSON – USA in Long Beach, CA. Other manufacturers will be considered, providing equipment meets or exceeds the quality specified and they can provide equipment of the type, size and function required. Substitutions must be approved by the Owner prior to this Bid Submission.
- C. The selected model shall be EPSON model #BrightLink 485W WXGA 3LCD Projector with mount
- D. Specifications
 - 1. Projection System: EPSON 3LCD, 3-chip technology
 - 2. Projection Method: Front / Rear / Wall Mount / Table
 - 3. Driving Method: Poly-silicon TFT Active Matrix
 - 4. Pixel Number: 1,024,000 dots (1280 x 800) x 3
 - 5. Color Brightness (Color Light Output): 3100 lumens¹
 - 6. White Brightness (White Light Output): 3100 lumens¹
 - 7. Interactive Color Brightness (Color Light Output): 3100 lumens¹
 - 8. Interactive White Brightness (White Light Output): 3100 lumens¹
 - 9. Aspect Ratio: 16:10
 - 10. Native Resolution: 1280 x 800 (WXGA)
 - 11. Lamp Type: 215 W UHE

12. Lamp Life:
 - ECO mode: Up to 4000 hours²
 - Normal mode: Up to 3000 hours
13. Throw Ratio Range:
 - 4:3: 0.33 – 0.44
 - 16:9: 0.27 – 0.37
 - 16:10: 0.27 – 0.37
14. Size (projected distance):
 - 4:3: 53" – 88"
 - 16:9: 59" – 97"
 - 16:10: 60" – 100"
15. Keystone Correction:
 - a. Manual
 - Vertical: ± 5 degrees
 - Horizontal: ± 5 degrees
16. USB Plug 'n Play:
 - Mac® 10.5 or later
 - USB Plug 'n Play for Windows® 2000 or later
17. Contrast Ratio: Up to 3000:1
18. Color Reproduction: 16.77 million colors
19. Projection Lens
 - a. Type: Manual focus
 - b. F-number: 1.80
 - c. Focal Length: 3.71 mm
 - d. Zoom Ratio: Digital zoom 1.0 – 1.35x

2.3 SMARTBOARD CLASSROOM SOUND SYSTEM

- A. The selected manufacturer shall be **Lightspeed Inc**, – USA in Tualatin, OR, ph: 503-684-5538, www.lightspeed-tek.com. Other manufacturers will be considered, providing equipment meets or exceeds the quality specified and they can provide equipment of the type, size and function required. Substitutions must be approved by the Owner prior to this Bid Submission.
- B. The selected model shall be TOPCAT Ceiling-mount classroom audio with wireless integration.
- C. SYSTEM OVERVIEW
 1. The system must have specifications and features that are equivalent to the Lightspeed TopCAT In-Ceiling Classroom Audio System including the following:
 - a. All-in-one unit with integrated infrared sensor/receiver, amplifier, and speakers
 - b. Two-way hybrid speaker system with NXT™ distributed mode speaker technology and low frequency cone driver.
 - c. Cross over technology to deliver high speech intelligibility and full range sound with even distribution throughout the classroom
 - d. Two IR channels with independent volume controls
 - e. Pendant-style REDMIKE™ VC classroom microphone with audio input
 - f. Wireless audio inputs from wireless Media Connector
 - g. One wireless audio output to the Media Connector
 - h. PageFirst emergency page priority
 2. The system must produce high speech intelligibility and full-range multimedia quality sound with excellent distribution throughout a classroom

3. The system must be capable to be installed in a classroom with no wires installed in or on the walls. The system must be fully operational without speaker wires or sensor cables
4. The system shall carry a standard warranty equivalent to the Lightspeed 5-year Warranty

D. ALL-IN-ONE SYSTEM SPECIFICATIONS

1. Overall System
2. Power output: 20 Watts rms
3. Acoustic Frequency response: 60 Hz to 18 kHz -10dB
4. Dimensions (W x D x H): 24" x 24" x 3"
5. Weight: 16 lbs
6. Controls
 - a. (1) Power switch with LED
 - b. (2) IR microphone volume controls
7. Connections:
 - a. (1) AC Power input
 - b. (1) DC Power Input
 - c. (1) Page mute (PageFirst™) input (Euro-block)
8. Integrated Infrared Sensor/Receiver:
 - a. Total Diodes: 32
 - b. Reception Coverage: up to 1600 square feet
 - c. Signal-to-noise: >77 dB
 - d. Image and Spurious Rejection: >70 dB
 - e. Total Harmonic Distortion: <1%, 1 kHz
 - f. Standard sub-carrier frequencies: 2.06/2.54 MHz
 - g. Receiver Sensitivity: 6 μV for 60 dB S/N
 - h. Reception Selectivity: ±40 kHz
9. The in-ceiling classroom audio system shall use bi-directional DECT wireless transmission technology to integrate with other audio sources in the classroom.
10. The in-ceiling classroom audio system shall use bi-directional DECT wireless transmission to send a mixed audio output to a receiver/transmitter located at a convenient/student accessible location in the classroom.
11. The all-in-one system must contain a Page mute function (PageFirst™) that passively detects the audio signal of a page coming through the PA system without compromising system performance or voiding warranties. As an audio signal is sent to the PA speaker, the PageFirst™ detects that signal and immediately mutes the REDCAT Media.
12. The all-in-one audio system shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS compliant).
13. The all-in-one audio system shall be manufactured in the USA.
14. The receiver/amplifier shall be CE certified.

E. REDMIKE VC PENDANT-STYLE IR MICROPHONE / TRANSMITTER

1. Qty 1 per speaker location is required.
2. Description: the pendant-style REDMIKE VC transmitter shall be capable of being worn around a teacher's neck as a hands-free microphone via the lavalier cord or to be used as a handheld student pass-around microphone. The REDMIKE VC must be rechargeable via cradle charger and must have alkaline charge protection.
3. Standard sub-carrier frequencies: 2.06/2.54 MHz, Alternative sub-carrier frequencies: 3.20/3.70 MHz
4. Audio distortion: <1%
5. Integrated microphone type: uni-directional electret.
6. Input jack for audio source or optional external microphone: 3.5mm

7. Microphone input impedance: 2.2k Ω
8. Alkaline Charge Protection: Yes
9. Battery Charger: cradle charger (charges two REDMIKE VC transmitters)
10. Cradle Charger input: mini DC jack
11. Cradle Charger Output Jack: 3.5mm DC output jack for LT-71 or HM-70 transmitters
12. Battery Power: One (1) AA NiMH Lightspeed rechargeable battery (Part# BA-NH2A27)
13. Dimensions: 3.5" (h) x 0.9" (w) x 1.0" (d)
14. Weight (with battery): 2.1 oz.
15. The REDMIKE VC pendant-style transmitter shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS compliant).
16. The REDMIKE VC pendant-style transmitter shall be CE certified.

F. REDMIKE VC INFRARED MICROPHONE WITH VOLUME CONTROL

1. Qty 1 per speaker location is required.
2. Description: the pendant-style REDMIKE VC infrared microphone/transmitter shall contain microphone volume control on the unit allowing teachers to adjust volume level from anywhere in the classroom. The microphone must be capable of being worn around a teacher's neck as a hands-free microphone via the lavalier cord or to be used as a handheld student pass-around microphone. The REDMIKE VC must be rechargeable via cradle charger and must have alkaline charge protection.
3. Standard sub-carrier frequencies: 2.06/2.54 MHz.
4. Alternative sub-carrier frequencies: 3.20/3.70 MHz, Alternative sub-carrier frequencies: 3.20/3.70 MHz
5. Audio distortion: <1%
6. Integrated microphone type: uni-directional electret.
7. Input jack for audio source or optional external microphone: 3.5mm
8. Microphone input impedance: 2.2k Ω
9. Alkaline Charge Protection: Yes
10. Battery Charger: cradle charger (charges two REDMIKE VC transmitters)
11. Cradle Charger input: mini DC jack
12. Cradle Charger Output Jack: 3.5mm DC output jack for LT-71 or HM-70 transmitters
13. Battery Power: One (1) AA NiMH Lightspeed rechargeable battery (Part# BA-NH2A27)
14. Dimensions: 3.5" (h) x 0.9" (w) x 1.0" (d)
15. Weight (with battery): 2.1 oz.
16. The REDMIKE VC pendant-style transmitter shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS compliant).
17. The REDMIKE VC pendant-style transmitter shall be CE certified.

G. WIRELESS MEDIA CONNECTOR

1. Qty 1 per speaker location as described on technology drawings.
2. Description: Integrates with classroom audio sources to send the audio wirelessly to the TopCAT system in the ceiling.
3. Audio Inputs: (4) 3.5mm stereo jacks connect to classroom audio sources.
4. Audio Output: (1) 3.5mm jack with volume control.
5. Audio frequency response: 80 Hz to 7 kHz \pm 3 dB
6. Audio distortion: <1%
7. Power: 5V 1.0 Amp wall power supply or power via USB cable (provided) from a computer.
8. Mounting: wall or table-top.

PART 3 - EXECUTION

3.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

3.2 EXAMINATION

- A. Examine room conditions, ceiling and wall surfaces to assure they are in compliance with requirements and other conditions affecting installation and operation of Interactive Whiteboards projectors and speakers.
- B. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to A/V cabling and other conditions affecting installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 CABLING

- A. All Audio Visual and associated cabling required for each system specified within this document is to be furnished, installed, terminated and tested as part of this section.
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
- C. 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.
- D. Splices, Taps, and Terminations: For control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 FIELD QUALITY CONTROL

- A. Verify that accessories required for each unit have been properly installed.
- 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. 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.
3. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation.

3.5 CLEANING

- A. Remove rubbish and debris: Installation contractor is not allowed you use the onsite dumpster and is responsible to discard their own debris off site.
- B. Clean installed items using methods and materials recommended in writing by manufacturer.

3.6 DEMONSTRATION

- A. Bidding contractor shall engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain each system described within this specification for the audio visual equipment. This training shall include (40) hours, in the blocks of hours that shall be described by the Owner.

END OF SECTION 274100

SECTION 275116 - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

1. Central Control sound system
2. Volume limiter/compressors
3. Speakers
4. Loudspeakers
5. Preamplifiers
6. Power amplifiers
7. Local Sound Systems
8. Microphones
9. Wireless microphone systems
10. Equipment cabinet
11. Equipment rack
12. Telephone paging adapters
13. Assisted listening
14. Noise-operated gain controllers
15. Battery backup power unit
16. Conductors and cables

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Division 01 Section 019113 General Commissioning Requirements.
- C. Related Drawings
 1. Txx Technology Plans (16 pages)
- D. Related Sections:
 1. Division 275313 Section "Clock Systems".
 2. Refer to the phasing plan.

1.3 SCOPE OF WORK

- A. Description
 1. This project shall be as phased approach as specified within the phasing section of this bid manual. The scope of work required as part of this project shall include a temporary

- service feed from the existing Public Address system to the new spaces. This temporary cabling shall be replaced with a permanent cabling during the phased renovations of the High School.
2. This temporary feed shall include the following:
 - a. Copper speaker cabling between the existing Public Address systems and all new spaces so that no occupied section of this facility shall not be without connectivity to the existing Public Address system.
 - b. After renovation to each section, the permanent cabling shall be utilized for all above connectivity. This new cabling is specified within the bid documents.
 3. Contractor shall furnish and install a complete school wide sound, intercom system, hereafter referred to as "Sound System", including central control sound rack, loudspeakers, wiring, conduit, supports, boxes, equipment and accessories shown on the Drawings and as specified herein and as required to provide a complete system including but not limited to:
 - a. Administrative display phone with integrated 4x16 character display
 - b. Handsets
 - c. Call Switches
 - d. Classroom speaker(s), ceiling- or wall-mounted
 - e. Call initiation switches capable of placing normal, urgent or emergency calls
 - f. Telemedia control of VCRs, DVDs, Video-On-Demand, and Blu-Ray
 - g. Built in Master Clock with 1024 events, 32 Schedules, including Daylight Savings Time, and 32 custom holiday events that can be assigned to any of the 64 multi-purpose zones
 - h. Wall-mounted paging horns
 - i. One built-in network interface port for system combining and LAN station-to-station calling and WAN access for district-wide all-calls and remote management
 - j. One built-in network interface port for first-time system configuration
 - k. Built-in Web Server for full system programming with Quantum Commander
 - l. Administrative Web-Browser Application for Programming and Day to Day System Operation
 4. Contractor shall provide local sound systems in the gymnasium. The local sound systems shall be interconnected with the main sound system described above, which shall be capable of overriding any local system for announcements made to areas covered by the local sound systems irrespective of whether the local systems are "ON" or "OFF".
 5. This described sound system shall integrate with the PBX within the school for complete access to this system from any handset part of the PBX.
 - a. System can connect to the PSTN (Public Switched Telephone Network) by connecting it to analog CO trunks.
 - b. Telephone service with public utilities shall be arranged by the owner, in conjunction with the equipment supplier. Equipment supplier shall generate a one-page document that will provide the Owner with information concerning number of outside lines (minimum of 8, and a maximum of 960 per school, maximum of 99 Schools [facilities]).

1.4 SYSTEM PARAMETERS

- A. The communication system shall be a **Bogen Quantum Multicom IP hybrid IP**, and shall provide a comprehensive communication network between administrative areas and staff locations throughout the facility. Non-volatile memory shall store permanent memory and

field-programmable memory. A system, which uses a battery to maintain system configuration information, shall not be acceptable.

- B. The system shall provide no less than the following features and functions:
1. Telephonic communication (complete with DTMF signaling, dial tone, ringing and busy signals, and data display) on administrative stations shall use two wires. Systems that use more than two wires for communication, tones and data display shall not be acceptable.
 2. Amplified-voice communication with loudspeakers shall use a shielded audio pair (shield can be used as one of the two required conductors for administrative phone or call-in switch).
- C. The system shall be available in the following configurations:
1. MC2K Wall-mounted in a custom enclosure Quantum. Station capacity shall be from 24 to 130 stations each Node. All stations shall have the ability to support displays.
 2. MC2KR Rack-mounted Quantum. Station capacity shall be from 24 to 250 stations each Node. All telephone stations shall have the ability to support displays.
 3. QRC24 & QRC48 Compact Quantum Rack System. Station capacity shall be from 24 to 48 stations per node. All stations shall have the ability to support displays, with an option to add up to 8 Central Office phone lines.
 4. 2223/2233 MC2KR Rack-mounted and integrated with Bogen Multi-Graphic Series 2223 or Series 2233 equipment. In this configuration, Quantum Multicom IP system station capacity shall be expandable up to 240 stations in increments of 24 per node. All telephone stations shall have the ability to support displays. The Multi-Graphic system equipment provides the following: backup fail safe intercom and paging functions (Note: the systems operate independently; if one were to fail, the other provides intercom for student safety), plus two additional program channels, and additional Multi-Graphic functions. It shall be possible, by use of a separate call-in switch, to annunciate only to the Multi-Graphic portion of the system without using additional station ports within the Quantum Multicom IP system. For switch banks to work effectively the equipment must be centrally located for switch-bank operation.
 5. The above system configurations represent a single processor in the Quantum Multicom IP. Each processor can be combined with up to 63 additional systems (nodes) for a total single facility capacity of up to 16,000 stations.
- D. The system shall consist of any combination of the following: Administrative Display Phones, Administrative VoIP Phones, and Administrative Phones.
1. Staff Classroom Stations shall consist of wall- or ceiling-mounted loudspeakers with call-in switches or handsets.
 2. Administrative phone stations shall consist of VoIP phones, display phones, or DTMF dialing 2500 analog-style telephone sets.
 - a. Up to 5 Administrative Wall Displays may be added to the Administrative Station for large office areas.
 3. Administrative Display Phones, Administrative VoIP Phones, and Administrative Phones shall have the option of including a loudspeaker.
 4. All types of stations except administrative VoIP phones shall utilize the same type of field wiring. Future station alterations shall only require the station type to be changed and the proper software designation to be selected. Alterations shall not require field wiring or system head-end alterations. All field wiring and system head-end equipment shall support any type of station, at the time of installation. All contractor proposals shall reflect this capacity. Failure to submit and bid this project in this manner will be deemed as being in direct conflict of these specifications and will be rejected.

5. There shall be no limit to the number of administrative display stations within the total capacity of the system including nodes. Systems that require different head-end equipment to make admin phone work shall not be acceptable.
 6. It shall be possible at any time to change the type of station at any location without equipment or wiring changes except for administrative VoIP phones that utilize existing LAN connections. Systems that limit the quantity of each station type or require future additional equipment and/or system expansion to provide additional administrative telephones shall not be accepted as an equal.
- E. The system shall be a global switching system, providing up to 512 unrestricted simultaneous private telephone paths per facility. The system shall also be capable of providing up to 512 amplified intercom paths per facility. One amplified intercom path shall automatically be provided with each increment of 24 stations of system capacity. All hardware, etc., required to achieve the necessary number of amplified-voice intercom channels for this system shall be included in this submittal. Amplified-voice intercom channels shall provide voice-activated switching. Systems requiring the use of a push-to-talk switch on administrative telephones shall not be acceptable. There shall be an automatic level control for return speech during amplified-voice communications. The intercom amplifier shall also provide control over the switch sensitivity and delay times of the VOX circuitry.
- F. The system shall provide 911 Dial-Through with specific outside line(s) dedicated only for this function to ensure that the line is available all the time for 911 calls. The 911 Dial-Through is available to any station that can dial.
1. The 911 CO lines will be pre-configured and reserved. If the 911 reserved lines are busy, the normal CO lines will be connected to route the 911 calls. If all the normal CO lines are busy, the ongoing call shall be disconnected and the 911 call shall be placed.
 2. When 911 is dialed from a Administrative VoIP Phone or Administrative Phone its Administrative Display Phone or Wall Display will receive a message that that room dialed 911.
- G. Emergency calls from staff stations shall receive prompt attention. An alternate destination in case the emergency call does not get answered at the primary location shall be configured as follows:
1. Staff-generated Emergency calls shall be treated as the second highest system priority. All Emergency calls shall announce at the top of the call queue of their respective administrative display phone. Should that emergency call go unanswered for 15 seconds, the call shall be re-routed to an alternate speaker station then a tone prompts the caller to make a verbal call for help. During the transfer, the original administrative telephone shall continue to ring the distinctive Emergency Ring. Should the Emergency Transfer to Station have an associated administrative telephone, it too shall ring the distinctive Emergency ring.
 2. The Emergency Transfer to Station shall be field programmable.
 3. Should the original administrative display phone be engaged in a non-emergency conversation, its conversation shall be automatically terminated, indicated with an alert tone, and then reconnected to the station that generated the Emergency Call.
 4. Should the administrative display phone be engaged in an emergency conversation, successive emergency calls shall log into the call queue as well as transfer to the Emergency Transfer Station for their verbal call for help. Upon termination of the initial emergency conversation, the next one shall immediately ring the administrative telephone.

5. Systems failing to transfer unanswered Emergency calls or failing to immediately connect to the administrative display phone shall not be deemed as equal.
- H. There shall be a System-Wide Facility Emergency All-Call feature. The Emergency All-Call shall be accessed from designated administrative phones or by the activation of an external contact closure which shall give the third audio program input emergency status. The Emergency All-Call function shall have the highest system priority and shall override all other loudspeaker-related functions including Time Tones, Normal All-Call or Zone Pages or Audio Distribution.
1. Considering that emergencies calls are to be treated with the highest level of concern. Systems which do not regard Emergency-All-Call page from an administrative station with the highest priority shall not be deemed as equal.
 2. Upon picking up the receiver and dialing "9", a menu shall appear on the display prompting the user to enter each subsequent digit. In this way, the user shall not be required to memorize complicated key sequences in order to access emergency functions.
 3. The Emergency All-Call shall capture complete system priority, and shall be transmitted over all speakers in the facility. It shall also activate an external relay, which can be used to automatically override volume controls and other systems.
 4. Systems without Emergency All-Call, or systems with All-Call that cannot be activated by external means, or which do not capture complete system priority or activate an external relay, shall not be acceptable.
- I. There shall be at least four Dedicated Emergency Alarm Tones. Each may be accessed by dialing a three-digit number from designated administrative display phone. These emergency tones should be separate from the time tones. Systems using external alarm generators, or having less than four emergency alarm tones shall not be acceptable.
1. Upon picking up the receiver and dialing "9", a menu shall appear on the display prompting the user to enter each subsequent digit. In this way, the user shall not be required to memorize complicated key sequences in order to access Emergency Alarm Tones.
- J. There shall be four (4) External-Function Relay Driver Outputs, accessible from designated Quantum Commander User or Administrative Display Telephones by dialing a four-digit number. These outputs remain set until accessed and reset at a later time. The user shall have the ability to review the status of each relay driver. A plain English menu, prompting the user through the fields without requiring the user to remember any dialing sequences shall support this feature. Systems that require the user to remember complicated dialing schemes or prompt the user via cryptic commands shall not be deemed equal.
1. The stations shall be capable of being programmed for security contact relays for use with magnetic locks, motion detectors, cameras or any low-voltage, dry contact creating device. System using security stations for control of external functions shall not be acceptable.
 2. Upon picking up the receiver and dialing "9", a menu shall appear on the display prompting the user to enter each subsequent digit. In this way, the user shall not be required to memorize complicated key sequences in order to access external relay functions.
- K. There shall be a program-material interface included with each node, which shall accept up to four (4) program input modules. Systems requiring an external program source interface shall not be acceptable.

- L. There shall be an outside line feature. The circuitry shall interface with the station ports of an external telephone system, and shall provide facilities for up to 960 incoming lines per facility which shall be designated by the user to ring "day" and "night" administrative display stations or administrative stations. Where an administrative display station is designated to receive outside line calls, the phone shall ring with a unique tone and the outside line number shall appear on the display panel. The option shall also provide the ability to make outside line calls from Administrative Display Stations or Administrative Stations. This ability shall be programmable for each phone and there shall be thirty-two Classes of Service available to any station. This feature shall be capable of supporting DID, DISA, and a Security DISA function.
 - 1. Cellular system access for Security is of the utmost concern. Wireless security page offers a password-protected Security DISA feature that shall be accessible only from authorized Police, Fire, Emergency personal or an off-premise security office, which monitors the facility's security system. It shall function as follows: upon confirmation of the password DISA number, the system shall allow security personnel to dial access any station and monitor the activity without pre-announce tone or the privacy tone. This will then allow the security office to determine exactly what the conditions are in the station and the actions need to be taken.

- M. The system shall provide for field-programmable three-, four-, five-, or six-digit architectural station numbers.

- N. There shall be an automatic level control for return speech during amplified-voice communications.

- O. Each station loudspeaker shall be assignable to any one, any combination, or all of 64 Multi-purpose zones or any of the 16,000 hard-wired zones per facility.
 - 1. Each station loudspeaker shall be assignable to any one, any combination, or all of 64 Multi-purpose zones. Systems with less than 64 Multi-purpose zones shall not be acceptable.

- P. There shall be thirty-two (32) Flexible Time-Signaling Schedules with a total of 1024 user-programmed events per facility. Each event shall sound one of user-selected tones or external audio. It shall be possible to assign each schedule to a day of the week, or manually change schedules from an authorized Quantum Commander User via Web browser or MCDS4 phone. Systems, which do not provide a minimum of thirty-two (32) flexible time-signaling schedules or a choice of eight (8) time tones plus external audio, shall not be acceptable.

- Q. An internal program clock (with battery backup) shall be included, allowing a total of 1024 user-programmed events per facility. It shall be possible to synchronize the internal program clock with an external master clock. Systems, which do not provide an internal program clock and/or can not synchronize with an external master clock to meet these specifications, are not equal.
 - 1. There shall be thirty-two (32) flexible time-signaling schedules. It shall be possible to assign each schedule to a day of the week, or manually change schedules from an authorized Quantum Commander User via Web browser on the LAN or WAN. Systems that require external equipment or server to perform these functions are not considered equivalent.
 - 2. The built-in Master Clock corrects time by accessing the LAN NTP time server.
 - 3. The Quantum Processor is capable of adjusting the Daylight Savings Time automatically.
 - 4. Each event shall be able to be directed to any one or more of the sixty-four (64) Multi-purpose time-signaling zones.

5. Each of the 64 Multi-purpose zones shall have a programmable "tone duration" unique unto itself. For example: the gymnasium can receive a time tone for ten (10) seconds while the rest of the facility receives a tone for five (5) seconds.
 6. Each event shall sound one of eight (8) user-selected tones or external audio. Each event may utilize a different custom tone. It shall be utilized to send the gymnasium, shop classes, and pool (if necessary), a separate time tone to indicate "clean up." Minutes later the entire facility can then receive the same time tone to indicate class change.
 7. Each of the eight (8) Distinct Time Tone Signals may be manually activated by selected Administrative Display Phones or an authorized Quantum Commander User via web-browser. These tone signals shall remain active as long as the telephone remains off-hook, or until canceled from the keypad or Quantum Commander.
 - a. Upon picking up the receiver and dialing "9", a menu shall appear on the display prompting the user to enter the next digit. In this way, the user shall not be required to memorize complicated key sequences in order to access manual time-tone functions.
 - b. Systems that do not provide at least thirty-two (32) flexible time signaling schedules or do not provide automatic activation of schedules shall not be acceptable.
- R. There shall be a zone-page/all-page feature that is accessible by selected administrative VoIP phones and administrative phones.
1. There shall be automatic muting of the loudspeaker in the area where a page is originating.
 2. There shall be a pre-announce tone signal at any loudspeaker selected for voice paging.
- S. There shall be a voice-intercom feature that is accessible by selected administrative phones, administrative VoIP phones and all administrative display phones.
1. There shall be a privacy tone every 16 seconds to signal at any loudspeaker selected for amplified-voice communication is in progress.
 2. There shall be a pre-announce tone signal at any loudspeaker selected for voice-intercom communication.
 3. Privacy and pre-announce tone signals shall be capable of being disabled during system initialization.
 4. There shall be an automatic switchover to private telephone communication should the person at the loudspeaker pick up his handset.
 5. By picking up the receiver and dialing the first digit of the number of the station to be called, that number shall appear on the display along with a loudspeaker symbol, prompting the user to enter the next digits. There should be no confusion as to type of conversation, whether speaker/intercom or telephonic to be established.
- T. There shall be a telephonic communication feature, which is accessible by all Administrative VoIP Phones, Administrative Phones, and Administrative Display Phones.
1. There shall be an audible ring signal announcing that a call has been placed to that station.
 2. Upon picking up the receiver and dialing * (star), a telephone symbol shall appear on the display, prompting the user to enter the number of the station to be called. There should be no confusion as to type of conversation, whether speaker/intercom or telephonic to be established.
 3. There shall be an automatic disconnect of Staff Handsets left off-hook to prevent them from tying up communications channels. The station shall receive a busy signal and shall

- automatically disconnect after 45 seconds. Systems shall also be capable of doing off hook emergency call-in.
4. There shall be an automatic disconnect of Administrative Display Phones and Administrative Phones to prevent them from tying up communications channels. When a phone goes off-hook and does not initiate a call within ten seconds, the station shall receive a busy signal and shall automatically disconnect after 45 more seconds.
 5. Staff and Administrative Phone Stations may be programmed to ring an Administrative Display Phone during day hours and another Administrative Display Phone during night hours. Day and Night Hours shall be user-programmable. Assignment of Staff Stations shall not be restricted to any particular Administrative Station. Systems that limit the number and assignment of staff call-in to particular Administrative Display Station of Administrative Stations shall not be acceptable.
- U. Administrative VoIP Phones shall receive dial tone upon going off-hook. Outgoing calls are made by dialing the desired station. Incoming calls can be directed to the telephone or to the associated loudspeaker for a hands-free reply. There shall be a switchover from loudspeaker to private telephone communication when a person picks up the handset and dials ##### and enter (check mark).
1. Administrative VoIP Phones shall be able to make a normal call to any Administrative Display Phone by dialing the number. They shall also be able to initiate an Emergency Call by dialing ****. Emergency Calls shall ring the Designated Day/Night Administrative Display Phone. The system shall provide for each station to have a PIN Numbers. By dialing the PIN at any system telephone, the administrator shall have access to emergency paging regardless of the restrictions on the particular phone being used.
- V. Administrative Phones MCESS or MCWESS shall receive dial tone upon going off-hook. Outgoing calls are made by dialing the desired station. Incoming calls can be directed to the telephone or to the associated loudspeaker for a hands-free reply. There shall be an automatic switchover from loudspeaker to private telephone communication should the person pick up the handset.
1. Administrative Phones shall be able to make a normal call to any Administrative Phone by dialing the number. They shall also be able to initiate an Emergency Call by flashing the hook switch four times. Emergency Calls shall ring the Designated Day/Night Administrative Display Phone and then their speaker will be connected to the emergency link station if not answered within a predetermined time period. The system shall provide for each station to have a PIN Numbers. By dialing the PIN at any system telephone, the administrator shall have access to emergency paging regardless of the restrictions on the particular phone being used.
- W. Administrative Display Phones shall be equipped with a 4x16 character alphanumeric display panel.
1. Administrative Display Phones shall receive dial tone upon going off-hook. Outgoing calls are made by dialing the desired stations. Incoming calls can be directed to the telephone or to the associated loudspeaker for a hands-free reply. There shall be an automatic switchover from loudspeaker to private telephone communication should the person pick up his handset.
 2. The display shall normally show the time of day and day of week, the current time signaling schedule, and the numbers of up to four stations calling in along with the call-in status of each station (normal, urgent, emergency). When dialing from the Administrative Display Phone, the display shall indicate the station number and type of station (loudspeaker or handset) being dialed.

3. The display shall also provide user-friendly menu selections to assist the operator when paging and distributing program material. Displays shall be in English with internationally recognized symbols for maximum ease of use. Systems, which require the operator to memorize long lists of operating symbols or control codes, shall not be acceptable.
 4. Administrative Display Phones shall be programmable for one of 3 station types for system access, as follows:
 - a. Shall permit dialing any station in the system; turn program material on/off at their location; scroll, erase and auto-dial call-waiting queue; make conference calls and transfer calls; call forward to other administrative stations; make all-zone pages and emergency all-zone pages; have access to outside lines and be designated to receive outside line calls.
 - b. Select and distribute or cancel program material to any combination of stations, paging zones, or all zones; set/reset alarm/external functions and zone paging.
 - c. Bump or join a conversation in progress, manually initiate time tones.
 5. Program selection, and its distribution or cancellation shall be accomplished from a designated administrative display telephone, with the assistance of the menu display system. Distribution and cancellation shall be to any one, or combination of speakers, or any zone(s), or all zones. It shall be possible to provide three program channels at the same time.
 6. It shall be possible, via an Administrative Display telephone, to manually initiate any of eight (8) tones or any of the emergency tones. The tones shall be separate and distinctly different from the emergency tones. The tone selected shall continue to sound until it is canceled, or until the administrative display phone is placed back on-hook.
 7. Each Administrative Display Phone shall maintain a unique queue of all stations calling that particular phone.
- X. System programming shall be from an authorized Quantum Commander User via Web browser. All system programming data shall be stored in nonvolatile memory. A valid username and password shall be required to gain access to the following programmable functions:
1. Station Initialization shall be accomplished from an authorized Quantum Commander User via web browser. All station initialization data shall be stored in nonvolatile memory. A password (separate from the password necessary for system programming) shall be required to gain access to the following station initialization parameters:
 - a. Programming and diagnostics shall be built into the Quantum Commander web server browser and be accessible only by authorized personnel. Diagnostics shall indicate passes and failures of system memory, system clock, all audio busses, tone generators, DTMF generators and decoders and the integrity of the field wiring.
 - b. Systems not capable of supporting web-based diagnostics and any computer interface for programming and diagnostics or supportive of built-in diagnostics for the end user shall not be deemed as equal.
 - c. Systems that require a serial to Ethernet converter requiring additional software on pc for programming are not deemed as equal.
- Y. Rollover EOL (End-Of-Line Device)
1. This feature shall be supported for all the Stations (Admin Display phone, analog phone or handset) configured with a loudspeaker. Based on the dialed sequence, intercom or telephonic call will be connected to the corresponding telephone/handset or speaker.
 2. If a handset station, configured with this feature, is busy when an Admin User calls the station, the call shall be rolled over to the associated speaker. If the speaker is also busy

- in this case, then the Admin can bump the conversation if enabled in CoS for the admin calling.
3. Rollover End-of-Line features is only available for the following station types
 - a. Admin Phone and Speaker
 - b. Analog Phone and Speaker
 - c. Handset and Speaker
 4. For calls initiated by a call switch or a non-dial handset, rollover to the admin speaker shall not happen.
- Z. Admin AAA Group (Always An Answer)
1. This is an Administrative Display Phone feature. This feature shall be programmed from the Commander software. A maximum of 10 Administrative Display Phones will be supported in an Admin Group and there shall be a maximum of 32 Admin Groups per facility.
 2. Once the Admin Group is set:
 - a. For normal calls, if the primary Day/Night Admin Phone is busy/no answer, all the phones in the Admin Group shall ring.
 - b. For emergency calls, if the primary day/night phone does not answer, all the phones in the Admin Group shall ring.
 - c. On no answer from any of the admin phones and if the emergency announce link is configured, the call shall be transferred to the emergency announce link as per the existing procedures. Administrative VoIP Phones do not have the emergency announce link functionality.
 - d. On answer from any of the Admin Group Phones, all the other phones shall stop ringing.

1.5 DEFINITIONS

- A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
- B. VU: Volume unit.
- C. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
- C. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.

1. The Contractor shall submit a complete wiring diagram, dimensional and descriptive Drawings of all equipment, in quadruplicate, for approval. Drawings of the Central Control Rack and Local Sound Systems shall indicate the location of equipment, and shall provide full descriptive details of all equipment including methods of mounting equipment, wiring details, etc. These Drawings and Product Data shall fully detail each item and give complete performance and operating characteristics of the item.
 - a. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Console layouts.
 - c. Control panels.
 - d. Rack arrangements.
 - e. Calculations: For sizing backup battery.
 - f. Retain subparagraph below if equipment includes wiring.
 - g. Wiring Diagrams: For power, signal, and control wiring.
 - h. Identify terminals to facilitate installation, operation, and maintenance.
 - i. Single-line diagram showing interconnection of components.
 - j. Cabling diagram showing cable routing.

- D. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components 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 supports and seismic restraints for control consoles, equipment cabinets and racks, and components.

- E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.

- F. Qualification Data: For qualified Installer.

- G. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, 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.

- H. Field quality-control reports.

- I. Operation and Maintenance Data: For public address and mass notification systems to include in emergency, operation, and maintenance manuals.

- J. Programming code and password for the system.

- K. Test results and certificate of completion of testing to the existing PA system.
- L. Two (2) Internal Wiring Diagrams of the central control sound rack, identifying
 - a. All terminations at the terminal strips: speakers and their locations.
 - b. Locations and interconnection between/among components within the rack.
- M. Submit a numbered Certificate of Completion for installation, programming, and service training, which identifies the installing technician(s) as having successfully completed the technical training course(s) provided by the system manufacturer.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Personnel certified by NICET as Audio Systems Level II Technician.
- B. All items of equipment shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections.
- C. The contractor shall be an established communications and electronics contractor that has had and currently maintains a locally run and operated business for at least 5 years. The contractor shall be a duly authorized distributor of the equipment supplied with full manufacturer's warranty privileges.
- D. The contractor shall show satisfactory evidence, upon request, that he or she maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The contractor shall maintain at his or her facility the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service
- E. the equipment being supplied.
- F. 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.
- G. Comply with NFPA 70.

1.8 SAFETY / COMPLIANCE TESTING

- A. The communications system shall bear the label of a Nationally Recognized Testing Laboratory (NRTL) such as ETL, and be listed by their re-examination service. All work must be completed in strict accordance with all applicable electrical codes, under direction of a qualified and factory approved distributor, to the approval of the owner.
- B. The system is to be designed and configured for maximum ease of service and repair. All major components of the system shall be designed as a standard component of one type of card cage.

All internal connections of the system shall be with factory-keyed plugs designed for fault-free connection.

- C. The printed circuit card of the card cage shall be silk-screened to indicate the location of each connection.

1.9 COORDINATION

- A. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - MANUFACTURERS

- A. Approved manufacturers for Public Address sound systems:
 - 1. Bogen Inc
 - 2. Rauland Corp
 - 3. Telecor Inc
 - 4. All sound system components shall be the product of the aforementioned companies and those indicated in the specifications. All systems and equipment shall fully meet the requirements of these Specifications.
- B. Approved manufacturers for other local sound system equipment include Shure, JBL, EAW, Yamaha, Electro-Voice, Crown, QSC, other approved equals and as indicated in their respective articles and paragraphs throughout this specification.
- C. Approved manufacturers for Assisted Listening Equipment:
 - 1. Listen Technologies Corp, Bluffdale, Utah, Ph: 800-330-0891 – www.listentech.com
 - 2. Williams Sound, Eden Prairie, MN Ph: 800-328-6190 – www.williamssound.com
- D. All systems and equipment, including those mentioned in the specifications by model/catalog numbers, shall nevertheless be specially modified to meet all the requirements of these specifications.
- E. The intent of this product is to establish a standard of quality, function and features. It is the responsibility of the bidder to insure that the proposed product meets or exceeds every standard set forth in this specification.

PART 3 - PRODUCTS

3.1 PUBLIC ADDRESS SYSTEM

- A. System: **Quantum Multicom IP** manufactured by **Bogen** Communications, Inc., Ramsey, NJ and Made in the United States of America
- B. System Overview:
 - 1. The Quantum hybrid IP intercom must be capable of supporting the existing Multicom 2000 hardware and functions as well as the new features across the Quantum Processor's

interfaced over the LAN. The VoIP capabilities of the QSPC1 Quantum Processor Card will enable the support of the features across the various processors' nodes. The sections below cover how the system will handle each of the existing and the new features in the QSPC1 product. Systems that do not allow the reuse of existing equipment or are not backwards compatible shall not be deemed acceptable. Systems that don't allow processors/nodes to be seamlessly integrated via the LAN are not considered equal.

2. Quantum Multicom IP
 - a. The Quantum facility shall have a minimum of one node/processor and a maximum of up to 64 interconnected nodes/processors. A maximum of up to 99 facilities can be interconnected into a Quantum hybrid IP district.
 - b. The station numbers, program buses, etc. shall be identified with a QSPC1#, Station card# and port# or QSPC1#, program#.
 - c. Audio Information will be transmitted between the processors on the LAN using VoIP technology. Quantum will utilize all of the existing Multicom 2000 hardware except the current processor card. Thus making Quantum Multicom IP backwards-compatible with existing Multicom 2000 systems.
 - d. The processor software shall be upgradeable via Quantum Commander. After rebooting the nodes the software upgrade will be complete. If for some reason the newly installed software will not boot properly, the system shall revert to the previous working software load.
 - e. It shall be possible for Quantum schools to make 'station-to-station' calls and 'inter-facility All-Call paging' to a single facility or all Quantum facilities in a district using VoIP technology. Systems that require software to be loaded onto an external server or computer to make 'station-to-station' calls and 'inter-facility All-Call paging shall not considered equivalent.
 - f. The primary QSPC1 shall be configured to act as a VoIP Call Manager for facility point-to-point calls. Using Quantum Commander, every facility shall be configured with the IP addresses of the primary QSPC1 systems of all the other known facilities (maximum of 98 additional), and an organizationally private multicast IP address is to use the 239.0.0.0/8 scope. Additionally, multicast best practices recommend avoiding 239.0.0.x, 239.0.1.x, and 239.128.1.x address scopes which shall be used for facility and inter-facility paging.
 - g. The maximum number of simultaneous inter-facility intercom calls supported is based on the actual performance of the WAN and the CPU load. The voice quality of the inter-facility calls may vary based on the WAN conditions the average network intercom call uses around 20 Kbps (uni-cast) audio distribution (i.e. mp3 player, AM/FM tuner and or CD player) uses around 250 Kbps (multi-cast).
 - h. The system shall facilitate the playing of audio clips repetitively played until stopped by the Quantum Commander User an administrative display phone MCDS4 or a dry contact closure.
 - i. A built-in Master Clock, with battery backup, shall be included to automatically control class change or other signals. The Master Program Clock shall have 1024 events that may be programmed into any of the 32 time signaling schedules, and/or 32 flexible holiday schedules. The schedules shall be nameable for easy selection when assigning schedules to days or in the event of an override. Systems that rely on external master clock shall not be considered equivalent.
 - j. Network Time Synchronization. The system shall be capable of periodic update/synchronization of the processor's time with a Network Time Server via the school's LAN network. The Quantum processor card checks the NTP Server time every hour. Systems that do not provide Network Time Synchronization will not be deemed equivalent.

- k. Network Failure – in the event of a network failure the multi-node facilities processors will continue to work autonomously providing the facility with all scheduled events stored in each of the nodes local non-volatile memory and ability to connect an administrative phone to the local node for paging in the event of network failure. Systems that do not provide autonomous operation shall not be considered equal.
 - l. Multi-Node Survivability – the system shall provide Multi-Node Survivability in the event of a processor card failure. If either the primary processor or secondary processor fails the remaining processor will take over as primary. Systems that do not provide Multi-Node Survivability shall not be considered equivalent.
 - m. Station in a Multi-Node system shall support any or all station types specified in section 2.02 A. 8. Systems that don't support all types of station or require different head end equipment are not considered equivalent.
3. Quantum Commander
- a. The processor utilizes a web-based programming tool. The Quantum Commander is built into the QSPC1 processor card and upon boot up, users can login to the Quantum Commander Web Server via their web browser. Systems that require software to be loaded onto an external server/pc for web-based programming shall not considered equivalent. Systems that require com port redirector software or serial to Ethernet adapters are not deemed equal
 - b. The Quantum Commander shall be divided into three access levels depending on user access credentials. Systems that do not provide at least three (3) Levels of access are not equivalent. The three levels are:
 - c. Only the Administrator and Technician shall have access to add/delete/modify the database objects.
 - d. Users shall have display only access to see the data objects that include configuration, alarms, and performance data and perform certain operations based on the user's CoS (Class of Service).
 - e. The following Menu Items must be available on the Multicom IP Quantum Commander:
 - 1) File - Open Database, New System, Save, Delete, Report and Exit, Upload Database, Download Database, Download Software, Diagnostics, Tones and Announcements, Relay Configuration, Program Distribution, Media Assignment, List Passwords, Add Password, and Change Password.

C. Central Control Console

- 1. Rack-mounted equipment shall be Bogen Model TCPER
 - a. 77" Rack
- 2. MCRMP / MCMP / QRC24-48 (Compact Rack System)
 - a. Rack Mount full, Mini-System, or Wall Mount panel. Shall include the following components:
 - 1) Quantum Processor Card QSPC1
 - 2) Analog Card
 - 3) Station Card
 - 4) Telephone Interface Card
 - 5) 5 volt / 12 volt Power Supply
 - 6) 26 volt Power Supply(s)
 - 7) Audio Program Module Interface Assembly
- 3. MCRMF / MCMF / QRC24-48
 - a. MCRMF Rack mounting mainframe. Includes built-in ventilation fans and the following circuit cards:

- 1) Quantum Processor Card
 - 2) Analog Card
 - 3) Station Card
 - 4) Telephone Interface Card
 - 5) Ribbon Cable Assembly
 - b. MCMF Wall Mount mounting mainframe. Utilizes convection cooling and the following circuit cards:
 - 1) Quantum Processor Card
 - 2) Analog Card
 - 3) Station Card
 - 4) Telephone Interface Card
 4. QRC24 / QCR48 Compact Quantum Rack System Mainframe (1 per Mini-System). Includes built-in ventilation fan and the following circuit cards:
 - 1) Quantum Processor Card
 - 2) Analog Card
 - 3) Station Card
 - 4) Telephone Interface Card
 5. MCRRP / MCRRC / MCRC
 - a. Ribbon Cable Assembly
 6. Program Sources
 - a. Tape Player & AM/FM Tuner
 - b. 5-Disc CD Player
 - c. AM/FM Tuner
 - d. Desktop Paging Microphone
 7. Power Amplifiers
 - a. 250-Watt Amplifier
 8. Station Equipment
 - a. Administrative Display Phone
 - b. Administrative Desktop Phone
 - c. Secure Call - Call Assurance Call-in Switch
 9. Additional Equipment required
 - a. Telephone Access Card
- D. Administrative Display Phone
1. Administrative Display Phones shall be **Bogen Model MCDS4**. The administrative telephone display panel shows the time of day and day of week, the current time signaling schedule, and the station numbers and call-in priority of staff stations that have called that particular station. A 3-key response is used to scroll the display, and answer or erase normal, urgent, and security calls. Depending upon the system programming, an administrative station can use display menus to activate zone pages, alarm signals and external functions, as well as select program sources and distribute or cancel a program to any or all speakers or zones.
 2. Administrative Display Phones shall have the ability to dial and have the option of dialing either the loudspeaker or phone at each station location. The system shall automatically switch from phone-to-intercom communication to phone-to-phone communication when the staff handset or enhanced staff phone on the receiving end of the call is lifted.
 3. The Administrative Display Phone shall display the classroom number of any station that calls 911. This feature will notify the main office when a classroom has dialed 911 emergency centers so that administrators can direct emergency personnel to the correct

physical location in the building when they arrive. Systems that do not provide this feature will not be deemed equal.

4. Administrative Display Phones shall have the ability to manually override the active schedule in the facility. Systems that do not have the ability to override the schedule via the administrative phone are not equal.

3.2 SPEAKERS

- A. Unless otherwise noted, this speaker shall be used as part of the speaker assemblies specified below.
- B. Classroom Speakers shall be Bogen:
 1. Ceiling Speakers: CSD2X2 Drop-In Ceiling Speakers
 2. Wall Speakers: MB8TSQ/SL Metal Box Speakers
- C. Hallway Speakers shall be Bogen:
 1. Ceiling Speakers: S86T725PG8W Drop-In Ceiling Speakers
- D. Flush mounted ceiling speaker assembly mounting accessories:
 1. Bogen #RE84 - Ceiling Speaker Enclosure or approved equal – The protective enclosure for the 8" cone-type loudspeakers shall be a Bogen model RE84, or equivalent, designed for recessed installations. It shall be constructed of one-piece heavy-gauge steel, and shall include a speaker-mounting ring. A foam insert shall be permanently attached to the inner surface, to prevent metallic resonance. Four combinations 1/2" – 3/4" conduit knockouts shall be provided at 90 degree intervals, and the unit shall be finished in a rust-resistant primer coating. The dimensions shall be: 12-1/4" dia. x 4-1/2" D.
 2. Bogen #MR8 - Mounting Ring or approved equal – The plaster ring shall be a Bogen model MR8, or equivalent, circular cold-rolled steel unit that will mount any Bogen ceiling grille. It shall be finished in a rust-resistant primer coating, and the dimensions shall be: 12" dia. x 3/4" D.
 3. Bogen #TB8 - Tile Bridge or approved equal – The load-bearing T-bar support shall be a Bogen model TB8, or equivalent, capable of sustaining the weight of an 8" speaker, grille and protective enclosure in suspended ceiling construction. It shall be manufactured of steel and shall be finished with a rust-resistant galvanized coating. The unit shall measure: 23-3/4" W x 3/4" H x 14-1/2" D.
4. Locker / Mechanical Room Speakers shall be Bogen:
 - a. FMH15T mounted in BBSM6 surface-mounted vandal-resistant enclosure/BBFM6 flush-mounted vandal-resistant enclosure with FMHAR8 adapter ring and SGHD8 heavy duty grille
5. Gymnasium/ Speakers shall be Electro-Voice or equivalent:
 - a. Electro-Voice #VSX100+
 - b. These speakers shall be mounted facing the seating in these rooms.
6. Outdoor Horn Speaker shall be Bogen:
 - a. KFLDS30T Wide Dispersion Reentrant Horn Loudspeakers
7. Hallway and Common Area Speakers shall be Bogen:
 - a. HFCS1 High-Fidelity Ceiling Speakers

8. Volume control for speakers
 - a. Provide a volume control for speaker in each location indicated within the architectural plans.
 - b. Volume control shall be equipped with an autotransformer and ten steps of attenuation, wall mounted to a single-gang bushed stainless steel plate at 4'-0" A.F.F.
 - c. Power rating shall be 10 watts. Input voltage shall be 25 volts or 70 volts. Attenuation range shall be 36 dB. Insertion loss shall be 0.5 dB or less.
 - d. Volume control shall be Bogen #ATP10A or approved equivalent.

E. Wire Guards

1. A guard shall be provided for each speaker where indicated on the Drawings.
2. The guard shall be rectangular in shape, constructed with 9-gage steel rods, zinc plated, epoxy finish; Color: White.
3. Guards shall be securely fastened to the wall.

3.3 LOCAL SOUND SYSTEM (LSS)

- A. The following equipment is required for these areas:
 1. GYMNASIUM #B113
 2. CAFETERIA #B105
- B. Contractor shall provide a local sound system per each area indicated above, which shall include:
 1. One (1) rack type amplifier.
 2. One (1) feedback eliminator.
 3. One (1) system for the hearing impaired as specified elsewhere within this written specification.
 4. One (1) wireless microphone distribution system.
 5. One (1) wall mounted cabinet and associated equipment.
- C. The system(s) shall provide audio mixing and amplification for:
 1. Minimum of four (3) low impedance dynamic microphones, but not less than the number of microphone outlets shown on the drawings.
 2. One (1) wireless microphones
 3. One (1) CD/MP3 Player/Recorder.
 4. One (1) Audio input from a remote iPod or DVD.
- D. Rack Type Amplifier: Rack type amplifier shall contain an eight-input mixer, various controls and a nine-band equalizers in a self-contained cabinet for rack mounting.

1. The rack type amplifier shall be Bogan, Peavey WMA150, Dukane 1A931, precedence/Bi-amp CMA120 or approved equal.
 2. The mixer shall provide controls for up to eight inputs using rotary potentiometers.
 3. The equalizer shall be a nine-band constant Q slide potentiometers, 63-16 KHz, with center-off detent for rapid "flat" setting. Each filter section shall allow up to 12 dB of cut or boost. Provide a cover plate to prevent tampering with equalizer setting.
 4. The amplifier shall be of the low-distortion, fully complementary symmetry type, providing 150 watts of output. The frequency response shall be a minimum of 20 to 20,000 Hz. +0/-1.2 dB (at 9 dB below rated output per EIA Standard SE-101A), with a direct-coupled distortion of less than 0.4% from 20-20 KHz at rated output. The amplifier output shall be user selectable as either direct-coupled or transformer-isolated (25V or 70V). The frequency response of the transformer-isolated outputs shall be +0/-1.6 dB, 20 to 20,000 Hz at 9 dB below rated output.
 5. The Local Sound System cabinet shall be approx. 35"H x 23.4"W x 17.3"D, with venting grilles on the sides. Cabinet shall be constructed of 16-gauge steel with panel mounting rails of 14-gauge steel. It shall be equipped with a hinged and lockable door. Deliver four (4) keys for each cabinet to the Authority. Cabinet shall be Middle Atlantic Model EWR-16-17 or approved equal.
 6. Provide appropriate modules for inputs from microphones, CD/MP3 player, VCR/DVD etc. Provide all cables, connectors and accessories for the sound system.
 7. The amplifier shall, at minimum be equipped with the following controls:
 - Illuminated power switch.
 - Master output volume control
 - High frequency cut switch (8 KHz, 12 dB/oct.)
 - Low frequency cut switch (140 Hz, 120 dB/oct.)
 - Equalizer bypass switch
 - Equalizer filter controls(9)
 - Mixer input controls (8)
- B. Feedback Eliminator
1. Provide a feedback eliminator to eliminate feedback without muting or muffling. The unit shall be fully connected to the local sound system. Feedback extermiator shall be Sabine #FBX-1020Plus or approved equal.

3.4 ASSISTED LISTENING EQUIPMENT

- A. Contractor shall provide a system for the hearing impaired for each local sound system as specified in the bid documents and this written specification.
- B. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers. Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.
- C. The system shall be frequency modulated and fully connected to the local sound system and the public address systems central console.
- D. The antennae shall NOT be mounted directly on the transmitter. It shall be mounted outside the housing cabinet at the location as directed within the architectural drawings.

1. Antenna shall be extended with antenna cable to the transmitter.
 2. All cabling from the antenna to the transmitter shall be procured and installed for a complete and functional system.
- E. Provide an additional eight (8) single channel receivers for the local sound system.
- F. Minimal specification on all equipment is based on the parts specified below, all substituted devices must meet or exceed this equipment.
- G. Equipment and quantities shall be provide in each area as described below:
- H. GYMNASIUM # B113
1. Total seating: 570
 2. Transmitter
 - a. Listen Technologies LT800-072 with LA-326 rack mounting kit. 72 MHz, Wide band frequency
 - 1) Quantity: 1
 3. Transmitter Antenna
 - a. Listen Technologies LA-122
 - 1) Quantity: 1
 4. Receiver
 - a. Listen Technologies LR-300 w/ LA-162, batteries
 - 1) Quantity: 23
 5. Replacement Cushion
 - a. Listen Technologies LA-163
 - 1) Quantity: 100
 6. Over-Ear Earphones
 - a. Listen Technologies LA-164
 - 1) Quantity: 23
 7. Neckloop Induction Coil
 - a. Listen Technologies LA-166
 - 1) Quantity: 6
 8. Portable Charging Case
 - a. Provide portable charging cases with total capacity equal to or greater than quantity of receivers specified above.
 - 1) Listen Technologies LA-311
 - 2) Quantity: As Required
- I. CAFETERIA #B105
1. Total seating: 148
 2. Transmitter
 - a. Listen Technologies LT800-072 with LA-326 rack mounting kit. 72 MHz, Wide band frequency
 - 1) Quantity: 1
 3. Transmitter Antenna
 - a. Listen Technologies LA-122

- 1) Quantity: 1
4. Receiver
 - a. Listen Technologies LR-300 w/ LA-162, batteries
 - 1) Quantity: 6
5. Replacement Cushion
 - a. Listen Technologies LA-163
 - 1) Quantity: 100
6. Over-Ear Earphones
 - a. Listen Technologies LA-164
 - 1) Quantity: 6
7. Neckloop Induction Coil
 - a. Listen Technologies LA-166
 - 1) Quantity: 2
8. Portable Charging Case
 - a. Provide portable charging cases with total capacity equal to or greater than quantity of receivers specified above.
 - 1) Listen Technologies LA-311
 - 2) Quantity: As Required

3.5 MICROPHONES – HARD-CABLED

- A. Microphone shall be **Shure SM58S** or approved equal.
- B. Microphone shall be a cardioid dynamic type with impedance suitable for use with the local sound system supplied.
- C. Microphone shall have a slide ON-OFF switch and a swivel attachment for mounting on floor stand. It shall have the following characteristics:
 1. Frequency response: 50 to 15,000 HZ
 2. Impedance: 350 ohm.
- D. Each microphone shall be supplied with a detachable, 25-ft heavy-duty flexible, 2-conductor shielded cable and a 3-pin XLR connector. Microphone cables shall be equipped, at the microphone receptacle end with approved XLR male plug.
- E. Microphones with floor stand shall be provided for each of the following systems in the quantity shown:
 1. GYMNASIUM #B113..... Quantity: 2
 2. CAFETERIA #B105..... Quantity: 2

3.6 MICROPHONES – WIRELESS

- A. The Wireless Combo system shall be the Shure ULXS124/85, or approved equal.

- B. The wireless system shall operate in the UHF band between 554 MHz and 865 MHz, with the specific available frequency range being dependent on the user's locale. Effective range of the system, receiver to transmitter, shall be 100 meters (300 ft.), under optimal conditions.
- C. The system shall allow selection of over 1400 operating frequencies across 36 MHz of bandwidth in order to avoid RF interference.
- D. Optimal frequencies shall be selected automatically, ensuring that individual systems run at their highest level of performance, and that multiple systems in simultaneous use do not interfere with one another.
- E. Each transmitter shall be powered by a single 9V battery. Transmitters shall have a power on/off switch, as well as a backlit LCD showing group and channel, peak indication, and battery strength.
- F. The transmitters shall include a body pack for use with electric guitars, basses, and other electric instruments, as well as lavalier or headset microphones, and a handheld microphone for vocals. The body pack shall include a -20dB pad switch to compensate for higher- or lower-gain devices.
- G. The receiver shall have a multi-function display showing group, channel, frequency, squelch level, transmitter battery strength, and locked/unlocked status. The system shall use diversity technology to improve reception, minimize signal dropouts, and achieve the best possible signal-to-noise ratio. Tone key squelch, and noise squelch circuitry shall be built in to the system to provide optimal sound quality and minimize unwanted noise. The receiver shall include an RF meter, an audio level meter, and a volume control.
- H. The ANTENNA that is required from the transmitter to the remote areas must be furnished and installed as part of this specification.
- I. Microphones with floor stand shall be provided for each of the following systems in the quantity shown:
 - 1. GYMNASIUM #B113..... Quantity: 2
 - 2. CAFETERIA #B105..... Quantity: 2

3.7 ANTENNA DISTRIBUTION FOR WIRELESS MICROPHONES

- A. The antenna distribution system shall be the Shure UA844SWB or approved equal.
- B. System shall be a Wideband UHF (470-952 MHz) Four-Way Active Antenna Splitter and Power Distribution System with an external power supply.
- C. For use with ULX and SLX receivers.
- D. Each antenna distribution system shall receive the following devices:
 - 1. Antenna: ½ Wave Omnidirectional receiver antenna
 - 2. Quantity: (2) per system
 - 3. Manufacturer: Shure #UA820H4 (518-574 MHz)

4. Antenna cable BNC to BNC cable from distribution equipment to antennas

3.8 WIRELESS MICROPHONE RECEPTACLE

- A. Microphone receptacles shall be three pin, XLR Type mounted to a stainless steel faceplate. Ground terminal shall not be connected to yoke. Microphone receptacles shall be switchcraft J3FS or approved equal. Each faceplate shall be inscribed "MIC-1", "MIC-2", "CENT. RACK", etc.

3.9 FLOOR STANDS

- A. Floor stand shall be a two-piece telescopic type, adjustable from 34" to 62" in height, and shall be locked securely in place by means of a positive grip-action clutch. The tube shall be rust-resistant steel mounted to a low profile base. The entire assembly shall be finished in charcoal gray. The floor stand shall be Whirelwind or approved equal.
- B. Quantity: 4

3.10 CABLING

- A. The Contractor shall provide wiring in raceway for the proper operation of the sound systems as called for in these Specifications, or as shown on the drawings. The types of cables required are as follows:
 1. Loudspeaker Cable: It shall contain three (3) 22 AWG stranded tinned copper conductors (2 aluminum-polyester shielded and 1 unshielded), plus a #22 AWG copper drain wire in a chrome PVC jacket. Conductors shall be polyethylene insulated with 0.014" thickness. Jacket thickness shall be 0.028" and overall outer diameter 0.21". Loudspeaker cable shall be Belden 8763 or approved equal.
 2. Microphone Cable: Cable shall consist of one (1) pair of 20 AWG stranded, tinned copper conductors, plus a #20 stranded drain wire in a chrome PVC jacket. Conductors shall be polyethelene insulated and aluminum-polyester shielded. Microphone cable shall be Belden No. 8760 or approved equal.
 3. UL-listed plenum rated cable shall be installed in environmental air spaces, including plenum ceiling.

3.11 RACEWAYS

- A. Conduit and Boxes: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
 1. Outlet boxes shall be not less than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

PART 4 - EXECUTION

4.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

4.2 INSTALLATION

- A. These Specifications do not enumerate all the details of fittings and accessory equipment required for proper operation of the systems herein described. It is under-stood that all necessary and required equipment shall be provided complete by the Contractor without extra compensation even though not specifically mentioned herein.
- B. The installation of the sound system and wiring shall be performed under the direct supervision of an authorized distributor of the sound system manufacturer.
- C. Provide labeling for each speaker cable termination onto the consolidation block. Label should indicate the speaker location and/or speaker array.
- D. The Integrator shall program the existing PA system to include all newly installed speakers and discrete sound systems.
- E. The installation, adjustment, testing and final connection of all conduit, wiring, boxes, cabinets, etc., shall conform to local electrical requirements and shall be sized and installed in accordance with manufacturer's approved shop drawings.
- F. Low-voltage wiring may be run exposed above ceiling areas where they are easily accessible.
- G. Contractor shall install new rack console at location shown on plans.
 - 1. Solder each speaker line splice and tape each individual wire.
 - 2. Connect remote slave clocks to master clock in console.
- H. All Administrative Phones shall be desk- or counter-mounted.
 - 1. Provide standard wall 120V AC receptacle 16" AFF
 - 2. Verify exact location with Architect
- I. Speaker and telephone lines run above ceiling and not in conduit shall be tie-wrapped to ceiling joist with a maximum spacing of 8' between supports. No wires shall be laid on top of ceiling tile.
- J. Connect field cable to each speaker transformer using UL butt splices for 22 AWG wire.
- K. Terminate field wiring on wall adjacent to rack using Telco 66 type blocks. Provide neat cross connect system for wiring. Wiring to be labeled to indicate final architectural room number that it services on the Telco block.
- L. Rack shall be labeled in numerical order with speaker/phone combinations first, speaker/outside horn combinations last. Labeling and order shall reflect final Architectural room numbers posted outside the rooms. Use three- (3), four- (4), five- (5), or six- (6) digit dialing extensions.

- M. Contractor shall provide a minimum of eight (8) hours of operational and programming instruction to school personnel.
- N. On the first school day following installation of Multicom System, the Contractor shall provide a technician to standby and assist in system operation.
- O. Mark and label all telephone outlets and/or sets with the graphic room numbers. Label all demarks IDF and MDF points with destination point numbers. Rooms with more than one outlet shall be marked XXX-1, XXX-2, XXX-3, etc. where XXX is the room number.
- P. No graphic room number shall exceed the sequence from 000001 through 899999.
- Q. Mounting of devices
 - 1. All speaker assemblies and other outlets shall be flush mounted, unless otherwise noted on drawings.

4.3 INSTALLATION OF CENTRAL CONTROL CABINET

- A. The Central Control Rack may be assembled in a configuration consisting of one, two, or three cabinets bolted together. The Contractor shall install this rack where shown on the Drawings or where directed. This rack shall be bolted to the floor, or as directed, in an approved manner.
- B. Cabinet Protection
 - 1. The supplier of the central rack shall, at the time of delivery to the job site of the central control rack, provide the Contractor with canvas covers to protect this equipment during installation and connection. The canvas shall be of such weight as to withstand normal handling and to protect the metallic surfaces against abrasions and droplets of paint from soaking through. The cover shall extend to within 1" of the floor, and shall be so constructed to permit the lower 24" to be rolled up or otherwise raised allowing access to the terminal strips.
 - 2. The covers shall be kept in place, except for necessary testing of the cabinet until all plastering, patching and painting in the vicinity is completed and in no event removed permanently until directed. The covers shall remain the property of the Contractor.

4.4 INSTALLATION LOCAL SOUND SYSTEM(S)

- A. The Contractor shall install all local sound systems as required by the Drawings and Specifications.
- B. The surface amplifier shall be flush mounted at a height that sets operating controls at approx. 4'-6" above the finished floor. Wall cabinet for hearing impaired, CD/MP3 player etc. shall be surface mounted at the same height.
- C. Set input level, equalizer and various controls of the local sound system to the satisfaction of the Authority.

4.5 LABELING

- A. Provide labeling for each speaker cable termination onto the consolidation block. Label should indicate the speaker location and/or speaker array.
- B. Provide a permanent label to identify each pushbutton, switch, control and outlet, etc. (tuner, cassette, CD, MP3, Mic.1, etc.). The label shall be mounted adjacent to the item it identifies. All labels shall be engraved or phenolic nameplates. Labeling using paper, glue or tape shall not be acceptable.

4.6 INSTALLATION OF SPEAKERS

- A. The Contractor shall install all local sound systems as required by the Drawings and Specifications.
- B. All speakers shall be cabled to the Category 5E consolidation block and then extended to the pre-existing PA headend located in the main Office.
- C. Set input level, equalizer and various controls of the local sound system to the satisfaction of the Owner.
- D. Speaker Settings:
 - 1. All outside speakers shall be on a separate paging zone and time zone.
 - 2. Speaker Tap settings:

1) Offices	(1) Watt
2) Classrooms	(1) Watt
3) Corridor	(2) Watts
4) Cafeteria	(2) Watts
5) Outdoor	(7.5) Watts
6) Mech. Spaces	(4) Watts

4.7 INSTALLATION OF SOUND SYSTEM WIRING

- A. All installations shall comply with NECA 1.
- B. Provide all conduits, conductors, boxes, receptacles, etc. indicated on the Drawings, herein specified, or required for the proper operation of the sound systems.
- C. Installation of all sound system wiring and all equipment shall be performed under the direct supervision of a C-EST certified Field Engineer.
- D. All Sound System conductors to and between the speakers and the Category 5E consolidation block shall be free from splices or other breaks.
 - 1. Interconnecting terminals as specified may be used only at terminals of loudspeakers, privacy switches, amplifiers, microphone receptacles, or where directed.
- E. All loudspeaker cables shall be terminated in the following manner:

1. The end connected to the loudspeaker transformer leads shall be neatly soldered and taped where such loudspeakers are not equipped with terminal strips. Where loudspeakers are equipped with terminal strips, the ends shall be equipped with U-type solderless lugs described above.
 2. Where two or more loudspeakers are on the same circuit, shall be soldered neatly to terminals of the loudspeaker transformers to form a "loop" circuit.
 3. Unused leads or taps of loudspeaker matching transformers shall each be separately taped to insulate the conductors from each other and from grounded parts of the equipment.
- F. All connections between/among components within the Central Control Rack shall be performed under the direct supervision of personnel authorized by the manufacturer of the Central Control Rack.
- G. All connections of conductors entering the Central Control Rack and terminated at the terminal blocks shall be performed by the Contractor.
- H. All connections shall be made under the direct supervision of the Manufacturer's Representative. Connections shall not be made until the Contractor and the Manufacturer's Representative have explained to the Owner's Representative the procedure to be followed.
- I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- J. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- K. All cabling shall be plenum rated and properly gauged per the distances of the devices from the central control station.
- L. Grounding
1. A dedicated # 10 ground wire shall be installed in conduit from the main ground bus of the electrical service and/or adequate building ground and attached to the frame of all the sound racks/cabinets and all required devices. Conduit bonds shall be used only for rack to rack continuities.

M.

4.8 PROTECTION

- A. The contractor shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.
- B. The contractor shall note in his system drawings, the type and location of these protection devices as well as all wiring information. Such devices are not to be installed above the ceiling.

4.9 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

Upon completion of the installation, contractor shall engage a factory-authorized service representative to perform overall performance test in the presence of the Owner's representative. Provide testing reports and certificate of completion of testing. The test shall include, but not be limited to the following:

1. Loudspeaker Circuits Test

- a. Transmit audio signals at normal levels over each loudspeaker circuit for determination of proper loudspeaker volume and clarity.
- b. Adjust transformer taps for proper output, as necessary.

2. Input Circuits Test

- a. Transmit audio signals at normal levels over each input circuit to determine proper operation of each input circuit. The test shall be performed using each of the two input selector switches over each of the two program channels. Each input source (tuner, CD/MP3 player, Mic., etc.) on the selector switch shall be tested.

3. Load Test

- a. Check for proper system operation when the entire system load (all speakers) is applied to either channel.

4. Communications Tests

- a. Initiate, by means of the central controls, two-way communications between classroom speaker and PA system.
- b. ALL-CALL via central controls: Check all speakers in the entire new building, including all local sound system speakers.
- c. Zone paging via central controls.
- d. For all other local sound systems, test all microphone outlets and other input sources as shown on the drawings.
- e. Test the system of the hearing impaired for proper function and operation as described by the manufacturer.

5. Local Sound Systems

- a. Transmit audio signals, using various input sources, over local sound system speakers for determination of proper loudspeaker volume and clarity. Adjust all settings, controls for proper output to the satisfaction of the Authority.

- b. For local sound systems, input circuits shall include all microphone outlets in the area, tuner, CD/MP3 player and audio input from VCR/DVD. Adjust feedback extermimator to achieve optimal result.
 - c. For all other local sound systems, test all microphone outlets and other input sources as shown on the drawings.
6. Signal-to-Noise Ratio Test:
- a. Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - 1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - 2) Repeat test for each separately controlled zone of loudspeakers.
 - 3) Minimum acceptance ratio is 50 dB.
7. Distortion Test:
- a. Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
8. Acoustic Coverage Test:
- a. Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
9. Power Output Test:
- a. Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
10. Signal Ground Test:
- a. Measure and report ground resistance at pubic address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
11. Inspection:

- a. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
- 12. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
- 13. Prepare test and inspection reports.
- 14. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

4.10 SERVICE / MAINTENANCE / WARRANTY

- A. The contractor shall provide a five year equipment warranty of the installed system against defects in material and workmanship. All materials shall be provided at no expense to the owner during normal working hours. The warranty period shall begin on the date of acceptance by the owner/engineer.
- B. The contractor shall, at the owner's request, make available a service contract offering continuing factory authorized service of this system after the initial warranty period.
- C. The system manufacturer shall maintain engineering and service departments capable of rendering advice regarding installation and final adjustment of the system.
- D. The Contractor shall submit a written warranty from an authorized distributor of the sound system that the system installed is free from defects in materials and workmanship, for the period of one year from the date of acceptance by the Owner. This warranty shall include all parts and labor.

4.11 DEMONSTRATION – TRAINING

- A. Bidding contractor shall engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain video-surveillance system.
- B. The vendor shall provide various levels of training including Manufacturer provided training as mandated by the Owner
- C. Sixteen (16) hours of training shall be included as part of this specification. These training hours shall be partitioned as the Owner mandates and as required.

4.12 GENERAL FIELD POLICY

- A. When inspecting or supervising the installation of equipment, manufacturers' representative shall be accompanied at all times by the technology consultant. In order to make the necessary arrangements, the Owner shall be notified at least 48-hours in advance of the manufacturer's representative visit to the School.

- B. Any changes of equipment shall be made only with the written permission of the technology consultant.
- C. Changes in location of equipment may be made only with the written permission of the technology consultant.
- D. All changes of location of equipment (including pull boxes, conduit runs, wire sizes, etc.) shall be incorporated in the As-built Sound/System Intercom Riser Diagram installed in the School.

END OF SECTION 275116

SECTION 275313 - WIRELESS CLOCK 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.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Division 01 Section 019113 General Commissioning Requirements.
- C. Related Drawings:
 - 1. Txx Technology Plans (16 pages)
- D. Related Sections:
 - 1. Division 275116 Section "Public Address and Mass Notification System".
 - 2. Refer to the phasing plan.

1.2 SCOPE OF WORK

- A. The Contractor shall provide a Wireless Clock System, including Global Positioning System (GPS) receiver, primary transmitter, satellite transmitter, analog clocks with batteries, conduit, wiring, etc., as shown on the Drawings and as indicated in the Specifications.

1.3 SUMMARY

- A. Section Includes:
 - 1. Wireless Clocks
 - 2. Wireless transceivers
 - 3. Wireless repeaters
 - 4. Conductors and cables

1.4 SYSTEM DESCRIPTION

- A. The Wireless Clock System shall continually synchronize clocks throughout the facility, and shall be capable of clock readouts in multiple time zones where desired.
- B. The system shall synchronize all clocks to each other. The system shall utilize GPS technology to provide atomic time. The system shall not require hard wiring. Clocks shall automatically adjust for Daylight Savings Time.

- C. Analog Clocks shall be synchronized to within 10 milliseconds no less 6 times per day, and the system shall have an internal oscillator that maintains plus or minus one second per day between synchronizations, so that clock accuracy shall not exceed plus or minus 0.2 seconds.
- D. The system shall include an internal clock reference so that failure of the GPS signal shall not cause the clocks to fail in indicating time.
- E. The system shall incorporate a “fail-safe” design so that failure of any component shall not cause failure of the system. Upon restoration of power or repair of failed component, the system shall resume normal operation without the need to reset the system or any component thereof.
- F. Clock locations shall be as indicated, and clocks shall be fully portable, capable of being relocated at any time.

1.5 REGULATORY REQUIREMENTS

- A. All equipment with digital Apparatus (microprocessors) that generate and utilizes timing signals at a rate in excess of 10,000 pulses per second to compute and operate, must be Federal Communications Commission (FCC) and “DOC” CSA Standards C108.8 (Electromagnetic Emissions) approved. Any equipment supplied or installed without the above approvals will not be accepted.
- B. Compliance with Government Regulations and Guidelines:
 - 1. FCC Class A: Compliant with FCC Part 15 Class A certification for minimal radiation in a classroom environment.
- C. Transmitter and receiver shall comply with Part 90 of FCC rules as follows:
 - 1. This device may not cause harmful interference.
 - 2. This device must accept interference received, including interference that may cause undesired operation.
 - 3. Transmitter frequency shall be governed by FCC Part 90.35.
 - 4. Transmitter output power shall be governed by FCC Part 90 257 (b)

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. In accordance with FCC regulations, an application for license must be filed prior to use of the equipment. The contractor shall submit a copy of the operating license to the Authority prior to installing the equipment. The original license shall be delivered to the school.
- C. Programming code and password for the system.

- D. Videotape of the personnel training.
- E. Test results and certificate of completion of testing.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Source Limitations: Obtain wireless clock system from single source.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved manufacturers of self-corrective clock systems and equipment are Bogan, Primex Wireless and Telecor. All equipment shall be the products of the same manufacturer and shall fully meet all the requirements of these Specifications.
- B. The intent of this product is to establish a standard of quality, function and features. It is the responsibility of the bidder to insure that the proposed product meets or exceeds every standard set forth in this specification.

2.2 EQUIPMENT

- A. The wireless clock system shall include a transmitter, a roof mounted GPS receiver, indicating clocks, and all accessories for complete operation.
- B. The wireless clocks shall be battery operated and shall include all batteries.
- C. GPS Receiver: shall be a complete GPS receiver including antenna in a waterproof case, 3-7/8 inches by 4-3/16 inches by 2 inches, designed for roof or outdoor mounting. Provide mounting bracket for attachment to roof structure and required attached cable.
- D. Primary Transmitter: shall be a wireless transmitter with GPS receiver, a surge suppressor/battery backup, and a mounting shelf. Unit shall obtain current atomic time from satellite. The clock system shall transmit time continuously to all clocks in the system.
 - 1. Transmission:
 - a. Frequency Range: 72.100 to 72.400 MHz.
 - b. Transmission Range: one mile, open field.

- c. Radio technology: narrowband FM
 - d. Number of channels: 16
 - e. Channel bandwidth: 20 kHz maximum
 - f. Transition mode: one-way communication
 - g. Data rate: 2 KBps
 - h. Operating range: 0°C to 70°C
2. Transmitter:
- a. Transmitter output power: +26 to +30 dBm
 - b. Frequency deviation: +/- 4 kHz
 - c. Transmitter power requirements: 120 VAC 60 Hz
 - d. Internal power requirements: 5 VDC
 - e. Carrier frequency stability: +/- 20 ppm
3. Transmitter shall have 16 selectable channels to assure interference-free reception.
4. Transmitter shall have the following switches:
- a. Time zone adjustment switches for Eastern Time zone.
 - b. Daylight Saving Time bypass switch.
 - c. 12-hour or 24-hour display.
5. Transmitter housing shall be black metal case, 16-3/4 inches by 12 inches by 1-7/8 inches in size.
6. Antenna shall be 46 inches high, commercial type, mounted on top center of transmitter housing. Antenna gain shall be < 2.2 dB. Antenna polarization shall be vertical.
7. Transmitter housing shall incorporate a display which shall include the following:
- a. Time readout
 - b. AM and PM indicator if 12-hour time display is set
 - c. Day and date readout
 - d. Indicator for daylight savings or standard time
 - e. LED which shall flash red in event of reception problem

- f. GPS reception indicator
 - 8. Transmitter shall contain an internal clock such that failure of reception from the GPS shall not disable the operation of the clocks.
- E. Power supply
- 1. Input: 120 volt AC 50/60 Hz, 0.4 amps.
 - 2. Output: 9 volt DC, 1.5 amps.
- F. Surge Protector/Battery Backup
- 1. Input: 120 volt AC 60 Hz, +/- 1 Hz
 - 2. Output: 120 volt AC, 500 VA, 300 watts
 - 3. Surge Energy Rating: 365 joules
- G. Additional Equipment
- 1. Wireless Receiver Switches: Switches shall receive time packets from the Primary Transmitter and relay the synchronized time to the Satellite Transmitter (Repeater) connected to it. The unit shall include the following:
 - a. Antenna mounted on top of the switch housing, 11-1/2 inches long
 - b. Power Supply:
 - 1) Input 120 VAC 50/60 Hz, 0.4 amps
 - 2) Output: 9 volt DC, 1.5 amps
 - c. RS 232 data cable, 5 feet long
 - d. Daylight Savings Time bypass switch
 - e. Dimensions: 4-1/4 inches long, 5-3/4 inches wide, 1-1/4 inches deep
 - f. Weight: 12 ounces
 - g. Operating Range: 32°F to 158°F (0°-70°C)
 - 2. Satellite Transmitter (Repeater) shall receive the signal from the Wireless Receiver Switches and transmit the signal to the devices in its vicinity, which are out of the range from the Primary Transmitter.
 - a. Antenna mounted on top of the housing, 46 inches long
 - b. Wireless Receiver Switch
 - c. Power Supply
 - 1) Input: 120 VAC, 50/60 Hz, 0.4 amps

- 2) Output: 9 volt DC, 1.5 amps
 - d. 6 foot cord
 - e. Surge Suppressor/Battery Backup
 - f. Mounting Shelf
 - g. Approximately one Watt transmission
 - h. 72 MHz frequency
- H. Analog clocks with batteries: Analog clocks shall be wall mounted where shown on drawings and dual-side wall mounted on the corridors. Clocks shall have polycarbonate frame and polycarbonate lens. Face shall be white. Hour and minute hands shall be black. Analog clocks shall be provided with red sweep second hand and shall be 12" diameter.
- 1. Clocks shall be Bogen #BCAL series or equivalent.
 - 2. Analog clocks shall be battery-operated, and shall have 5-year battery life.
 - 3. Analog clocks shall be capable of automatically adjusting for Daylight Saving Time. An on-off switch located on the transmitter shall disable this function if desired.
 - 4. Time shall be automatically updated from the transmitter 6 times per day.
 - 5. Analog clocks shall remember the time during changing of batteries.
 - 6. Analog clocks shall have a tamper proof/theft resistant clock lock mounting slots.
 - 7. Provide two D cells alkaline batteries per clock
 - 8. Analog clock receivers shall be as follows:
 - a. Receiver sensitivity: >-110 dBm
 - b. Receiver power: two alkaline D-cells
 - c. Antenna type: internal
 - d. Antenna gain: -7 dBd
 - 9. If transmitter stops transmitting valid time signals due to power failure, the clocks shall continue to function as accurate quartz clocks until a valid time signal is decoded.

2.3 WIRE GUARDS FOR CLOCKS

- A. Provide wire guards for clocks in gymnasium.

2.4 WIRING

- A. Provide duplex 3-wire grounded receptacle 20A, 125V next to the primary and satellite transmitter and connect to the emergency Panel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The GPS Unit shall be installed on the roof in clear view of the sky. The GPS Unit shall be located on a suitable bracket, well above the level of standing or incidental water and above accumulations of leaves or debris. Cable connection to GPS shall be sealed with cable connection sealant. Any added cable lengths must be protected from outside elements.
- B. Transmitter:
 - 1. Locate transmitter where indicated, a minimum of 2 to 3 feet above the floor, away from large metal objects such as filing cabinets, lockers or metal framed walls.
 - a. The installation contractor shall assure optimum performance of the Wireless Clock System. The preferred transmitter location for best transmission coverage is required of the contractor of this section.
 - b. Quantity and placement of these transmitters shall be included as part of this installation.
 - 2. Contractor shall attach receiver to transmitter using cable and connect antenna to transmitter, using care not to strip threads.
 - 3. Set the channel number on the display to correspond to the FCC license.
- C. Analog clocks with batteries: Contractor shall perform the following operations with each clock:
 - 1. Install batteries and set clock to correct time in accordance with manufacturer's instructions and verify that valid signals are received and analog clock adjusts itself to correct time.
 - 2. Install the analog clock on the wall in the indicated location, plumb, level and tight against the wall. Attach using clock-lock hanging method and suitable fasteners as approved by clock manufacturer.
- D. Wire guards: Secure to wall, using approved theft-resistant fasteners.
- E. Prior to final acceptance, clean exposed surfaces of clocks, using cleaning methods recommended by clock manufacturer. Remove temporary labels from clock faces. Do not remove labels from backs of clocks.
- F. All wiring shall be in raceway and shall conform to the requirements of the equipment manufacturers and the Specifications.

- G. Upon completion of the installation and prior to system acceptance, the system shall be tested under the supervision of the manufacturer's representative and in the presence of the Owner's Representative. Any and all defects and deficiencies shall be corrected to the Owner's approval at no additional cost.
- H. The test shall include a power failure simulation to test reset operation.

3.2 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.3 FIELD QUALITY CONTROL

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

- B. Tests and Inspections:

Upon completion of the installation, contractor shall engage a factory-authorized service representative to perform overall performance test in the presence of the Owners representative. Provide testing reports and certificate of completion of testing.

3.4 WARRANTY

- A. The Contractor shall submit a certificate from an authorized distributor of the wireless clock system, certifying that the installation of the entire system is in conformance with the requirement of the manufacturer.
- B. The Contractor shall submit a written warranty from an authorized distributor of the wireless clock system that the system installed is free from defects in materials and workmanship, for the period of one year from the date of acceptance by the Owner. This warranty shall include all parts and labor.

3.5 INSTRUCTION OF PERSONNEL

- A. The Contractor shall arrange with the authorized distributor of the wireless clock system, to instruct persons designated by the Owner in the proper operation and care of the wireless clock system. A minimum of two (1) 2-hour training periods shall be provided.
- B. The instruction shall include operating of the entire system.
- C. The Contractor shall arrange with the manufacturers of the equipment to instruct the BOE Custodian or building manager in the proper operation and care of the Wireless Clock System equipment. Provide Operation and Maintenance Manuals.
- D. Training of BOE Custodian or building manager shall be videotaped by the trainer (or contractor). A minimum of two (2) 1-hour training periods shall be provided. Tapes shall be labeled and turned over to the Authority's Representative within forty-eight (48) hours of training completion.
- E. Deliver to the Authority three (2) sets of operating instructions and programming manual for the clock system.

- F. Programming code and password for the system.

3.6 3.09 GENERAL FIELD POLICY

- A. When inspecting or supervising the installation of equipment, manufacturers' representative shall be accompanied at all times by the Owner's Representative. In order to make the necessary arrangements, the Owner's Representative shall be notified at least 48-hours in advance of the manufacturer's representative visit to the School.
- B. Any changes of equipment shall be made only with the written permission of the Owner's Representative.
- C. Changes in location of equipment may be made only with the written permission of the Owner's Representative.

END OF SECTION 275313

SECTION 280500 - SECURITY CONDUCTORS & CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Drawings
 - 1. "T" Technology Plans
- C. Related Sections:
 - 1. Division 281600 Section "Intrusion Detection" devices.
 - 2. Division 280500 Section "Access Control" devices.

1.2 SUMMARY

- A. Description
 - 1. The awarded installation contractor of this section shall furnish and install all the cabling indicated within the architectural drawings associated with the Intrusion detection system and all access control devices associated with the secured doors. The access control devices shall be specified during the renovation phase of the High School.
- B. Section Includes:
 - 1. Pathways.
 - 2. Security cabling.
 - 3. Cable connecting hardware.
 - 4. Cabling system identification products.
 - 5. Electronic safety and security equipment coordination and installation.
 - 6. Common electronic safety and security installation requirements.

1.3 DEFINITIONS

- A. "Project Manager" shall mean the Owner's appointed representative.
- B. "As Necessary" shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.
- C. "As Required" shall mean work which is required for completed construction and is shown on the drawings or described in the project specification.
- D. "Install" shall mean to set in place complete with all mounting facilities and connections as required ready for normal use of service.

- E. “Substantial Completion” shall mean that the project is sufficiently complete to be utilized for its intended use as stated in the body of this written specification.
- F. “Conduit” shall include all fittings, sleeves, connections, hangers and other accessories related to such conduit.
- G. “Surface Metal Raceway” shall include all fittings, sleeves, connections, hangers and other accessories related to such raceway.
- H. “Concealed” shall mean hidden from sight, as in chases, furred spaces, shafts, fixed ceiling or embedded in construction.
- I. “Exposed”, shall mean not “concealed” as defined above.
- J. “Governmental” shall mean all municipal, state and federal government agencies.
- K. The words “Furnish”, “Supply” and “Provide” shall mean purchase, deliver to the job site, protect and provide interim storage and install in accordance with manufacturer’s specifications.
- L. Words “Approved Equal” shall mean any product which in the opinion of the Technology Consultant is equal in quality, arrangement, appearance, and performance to the product specified.
- M. “Cabling” shall mean cable assembly, raceway, conductors, fittings and any other necessary accessories to make a complete wiring system.
- N. “Product” shall mean any item of equipment, material, fixture, apparatus, appliance or accessory installed under this Division.
- O. Words in the singular shall also mean and include the plural, wherever the context so indicates, and words in the plural shall mean the singular, wherever the context so indicates.
- P. “Contractor” refers to the bidding/installation Contractor responsible for furnishing and installation of all work indicated within this specification.

1.4 SECURITY CABLING DESCRIPTION

- A. Security cable and its connecting hardware provide the means of transporting signals between the remote security devices and the main hardware located within the communications equipment rooms.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated and utilized.
- B. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Codes and Standards:

1. All materials and workmanship shall comply with the latest additions of all applicable Codes, Specifications, Local and State Ordinances and Industry Standards.
2. The Contractor shall promptly notify the Construction Manager in case of conflict between Building Codes, State Laws, Local Ordinances and the Contract Documents.
3. Should the Contractor perform any work that does not comply with the requirements of the applicable Building Codes, Local Ordinances and Industry Standards, they shall bear all costs arising in correcting the deficiencies.
4. The Contractor, for the work in their scope, shall give all necessary notices, obtain all permits, pay all governmental taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. The Contractor shall obtain all required Certificates of Inspection for his respective work and deliver same to the Construction Manager before request for acceptance of their work is made and before final payment.

1.7 COORDINATION

- A. Coordinate layout and installation of security pathways and cabling with Owner's telecommunications and LAN equipment and Security service suppliers.
- B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Belden CDT Inc. Electronics Division.
 2. West Penn.
 3. Approved Equivalent.
- B. Cabling size and conductor quantities are described within the architectural drawing package.

2.2 SLEEVE SEALS

- A. Sleeves shall be adequately sized for the conduits and cables to be installed, with sufficient free space to install sealing caulk or putty. All sleeves will be fabricated of 1" minimum O.D. EMT, de-burred, material with a plastic or metal collar securely fastened to each end.
- B. Where penetrations are within floor slabs and fire rated partitions, pack the annular space between the sleeves and the conduit or cables with fire-retardant putty. The sealant material shall be intumescent, asbestos free and installed in accordance with UL and the manufacturer's instructions.

- C. Fire-retardant sealer and system shall be UL listed for the application and meet ASTM E-84, ASTM E-814, and UL 1479 requirements. Use Nelson “FSP” or approved equal.
- D. If Contractor elects to utilize any penetration which may currently exist, then it is the Contractor's responsibility to properly sleeve and firestop that penetration prior to completion of project.

2.3 FIRESTOPPING

- A. All conduits etc., passing through fire rated floors, walls and partitions, shall have the space between the raceways, sleeves and all penetrations filled with a reusable fire stopping material such as Firestop Putty, Adhesive Firestop Sealant or Firestop Compound as manufactured by STI or approved equal.

2.4 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. All security cabling shall be labeled at both ends.

2.5 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Testing: Continuity of cabling shall be performed and test results submitted to the Owner.

PART 3 - EXECUTION

- 3.1 All locations shown on the Architectural drawings are for approximation purposes only and must be field verified prior to installation. 10' service loops are required to enable terminations subsequent to device installation.

END OF SECTION 280500

SECTION 280528 - PATHWAYS FOR SECURITY 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.
- B. Related Drawings
 - 1. Txx Technology Plans (16 pages)

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Metal wireways and auxiliary gutters.
 - 5. Nonmetallic wireways and auxiliary gutters.
 - 6. Surface pathways.
 - 7. Boxes, enclosures, and cabinets.
 - 8. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
 - 2. Section 270528 "Pathways for communication systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal 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 certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Alpha Wire Company.
4. Anamet Electrical, Inc.

5. Electri-Flex Company.
 6. O-Z/Gedney; a brand of EGS Electrical Group.
 7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.
 8. Republic Conduit.
 9. Robroy Industries.
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company; a division of John Maneely Company.
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Arnco Corporation.
 - 5. CANTEX Inc.
 - 6. CertainTeed Corp.
 - 7. Condux International, Inc.
 - 8. Electri-Flex Company.
 - 9. Kraloy.
 - 10. Lamson & Sessions; Carlon Electrical Products.
 - 11. Niedax-Kleinhuis USA, Inc.
 - 12. RACO; a Hubbell company.
 - 13. Thomas & Betts Corporation.

- B. General Requirements for Nonmetallic Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.

- C. RNC: Type EPC-40-PVC complying with NEMA TC 2 and UL 651 unless otherwise indicated.

- D. Rigid HDPE: Comply with UL 651A.

- E. Continuous HDPE: Comply with UL 651B.

- F. RTRC: Comply with UL 1684A and NEMA TC 14.

- G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

- H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Alpha Wire Company.
 - 2. Arnco Corporation.
 - 3. Endot Industries Inc.

4. IPEX.
5. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

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. Cooper B-Line, Inc.
2. Hoffman; a Pentair company.
3. Mono-Systems, Inc.
4. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250 and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

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. Allied Moulded Products, Inc.
2. Hoffman; a Pentair company.
3. Lamson & Sessions; Carlon Electrical Products.
4. Niedax-Kleinhuis USA, Inc.

B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

- C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SURFACE PATHWAYS

- A. General Requirements for Surface Pathways:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mono-Systems, Inc.
 - b. Niedax-Kleinhuis USA, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.
- C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems Division.
 - b. Lamson & Sessions; Carlon Electrical Products.
 - c. Mono-Systems, Inc.

- d. Panduit Corp.
- e. Wiremold / Legrand.

2.7 BOXES, ENCLOSURES, AND CABINETS

- 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. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. Hoffman; a Pentair company.
 - 6. Hubbell Incorporated; Killark Division.
 - 7. Lamson & Sessions; Carlon Electrical Products.
 - 8. Milbank Manufacturing Co.
 - 9. Molex; Woodhead Brand.
 - 10. Mono-Systems, Inc.
 - 11. O-Z/Gedney; a brand of EGS Electrical Group.
 - 12. RACO; a Hubbell company.
 - 13. Robroy Industries.
 - 14. Spring City Electrical Manufacturing Company.
 - 15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
 - 16. Thomas & Betts Corporation.
 - 17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-B.
 - 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- F. Metal Floor Boxes:
 - 1. Material: Cast metal
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- J. Device Box Dimensions: as specified within the architectural drawings.
- K. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, with continuous-hinge cover with flush latch unless otherwise indicated.
 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures:
 - a. Material: Plastic.
 - b. Finished inside with radio-frequency-resistant paint.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Damp or Wet Locations: GRC.
 6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
 7. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
 8. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.

- C. Pathway Fittings: Compatible with pathways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. EMT: Use setscrew or compression, cast-metal fittings. Comply with NEMA FB 2.10.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface pathways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

5. Change from ENT to RNC, Type EPC-40-PVC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
 1. Use EMT, IMC, or RMC for pathways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- R. Surface Pathways:
 1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
 2. Install surface pathway with a minimum 2-inch radius control at bend points.
 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

- T. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.

- U. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service pathway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.

- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

- W. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.
- DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 280528

SECTION 281300 – ACCESS CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Access Control System, including software: Paxton Access Ltd
- B. Proximity Devices (Card Readers): Paxton Proximity Readers
- C. Motion Detectors Request to Exit Devices (REX) (RTE)
- D. Door Contacts
- E. Intercom/Door release with Video: Paxton Net2 Entry

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. Division 28 Section “Intrusion Detection”.
 - 2. Division 28 Section "Video Surveillance”.
- C. Refer to the following construction documents for Data Room locations and device locations only.
 - 1. T Technology Plans

1.3 SUMMARY

- A. Section includes a network controlled; access control system consisting of Proximity Readers, REX’s and Door contacts, with associated installation and configuration of the equipment.
- B. Section also includes an intercom – door release with video surveillance camera.
- C. The awarded contractor of this section shall furnish and install a network access controlled system into this facility using electronic security devices. This integrated access control system shall incorporate a series of proximity card access readers, door contacts, REX motion detectors and all associated monitoring and recording software, hardware, configuration, testing and training.
- D. **This Access Control System described within this specification shall be fully integrated with the video surveillance, intrusion detection, intercom door release and fire alarm systems. Complete interface of these systems, including user access and browser interface of the Exacq Vision network managed system to this Paxton Net2 Plus platform is the**

responsibility of the bidding contractor of this section.

- E. All installation, peripheral devices, required licensing and configurations are required as part of this specification to establish a coherent, functional system as described within this bid package.
- F. Security control and network cabling to/from the equipment rooms to the controlled doors, as described within the documents have been furnished and installed by other trades and shall be coordinated with the contractor awarded this section. These cables have been installed up to the junction box adjacent to every door.
- G. Any and all additional interconnection cabling required for a functional system shall be furnished and installed by the contractor awarded this portion of work.
- H. Final terminations to all devices are required by the bidding integrator of this portion of work.
- I. The electric strikes and power devices for these strikes are furnished and installed by others; only the connectivity and configuration of these devices to a “fail-secure” state is required by the awarded contractor of this portion of work.
- J. The Integrator awarded this portion of work shall provide and install a complete integrated security system and all associated, terminations, supporting devices, configuration of system, testing and training in accordance with this Bid package.
- K. This specification is used to identify the requirements for an integrated access control system. The operator workstation(s) shall be used for database programming and storage of historical events and as a User interface with the Video Surveillance System.
- L. This system shall be integrated with the building’s fire alarm system for proper activation of “fail-secure” locking mechanisms.
- M. All interconnections required to the fire alarm system shall be terminated by the fire alarm installers and shall be coordinated with the contractor awarded this portion of work.

1.4 SYSTEM CONFIGURATIONS:

- A. All system configuration(s) shall be included to attain a fully functional system and shall be within the Scope of work of the awarded contractor of this Bid package. This configuration shall include but not be limited to the following:
 - 1. Configuration of all controlled doors and devices.
 - 2. Configuration of all cameras shall be managed from this Exacq Vision Video Management software.
 - 3. Configuration of LAN switches – Active Electronics as required.
 - 4. Configuration of Paxton platform shall allow Client Server programming.

1.5 DEFINITIONS

- A. IP: Internet protocol.
- B. LAN: Local area network.

- C. WAN: Wide area network.
- D. AS NECESSARY: Shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.
- E. AS REQUIRED: Shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.
- F. SUBSTANTIAL COMPLETION: Shall mean that the project is sufficiently complete to be utilized for its intended use as stated in the body of this written specification.
- G. CONTRACTOR/INTEGRATOR: Refers to the bidding/installation Contractor responsible for furnishing and installation of all work indicated within this specification.

1.6 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions – System(s) shall withstand the environmental conditions without mechanical or electrical failure, damage or degradation of its operating capacity.

1.7 SUBMITTALS

- A. Product Data: Submit manufacturer's product specification sheets for every product to be used in this system within two (2) weeks of award of project. Product specification sheets must have the product being utilized and its part or model number visibly indicated. Product data shall include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Equipment and System Operation Description – Include the method of operation and supervision of each component and type of circuit. Show the sequence of operation for manually and automatically initiated system(s) or equipment inputs. Description must cover this specific project.
- C. Operation and Maintenance Data – For the intrusion/detection access control system, shall include the emergency, operation and maintenance manuals and shall include the Central-Station control unit hardware and software data.
- D. Include an itemized bill of materials and a detailed description of the proposed system(s) within the bid response. Any appendices are only intended to assist the contractor to formulate a bid. Quantities are estimated and should be verified by contractor.
- E. A copy of the Contractors Certified Installers S2 Certificate MUST be supplied within the bid response.
- F. Shop Drawings: For access control system shall be provided within two (2) weeks of system substantial completion acceptance. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes utilized.

- G. In the event that the installation contractor does not furnish or does not supply sufficient documentation, the owner has the right to engage a separate contractor to attain any or all required documentation. All costs related with this event shall result in a back charge to the installation vendor via a change order.
- H. Warranty: Sample of special warranty.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications – Installer must be a certified Level 2 or higher, factory trained, accredited and licensed installer for the manufacturers described within Article 1, 1.1 above.
- B. Installer Qualifications – A qualified manufacturer shall maintain a service center capable to provide training, parts and emergency maintenance repairs for the overall systems described within this Security specification and drawings. This response time must not exceed twelve (12) hour period.
- C. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NECA 1.
- F. Comply with NFPA 70.

1.9 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 temperature-controlled 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 twenty to ninety percent (20-90%) relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
 - 2. Interior, Uncontrolled Environment: System components installed in non- temperature-controlled 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 twenty to ninety percent (20-90%) relative humidity, noncondensing. Use NEMA 250, Type 3R 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 twenty to ninety percent (20-90%) relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick. Use sufficiently rated NEMA 250 enclosures.
 - 4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible

- dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
- 5. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use sufficiently rated NEMA 250 enclosures.
- 6. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.10 WARRANTY

- A. The Integrator guarantees the Systems to be installed under this specification to be free from any defects in workmanship and materials for a period of one (1) year from the date of final completion/acceptance of the project by the Owner as evidenced by the date of final payment for the work. The Contractor shall promptly and at their own expense remedy any defects in the work and pay for any damage to other work resulting thereof, which shall appear during the period of time covered by this guarantee. Neither the final certificate of payment nor any provisions in this Agreement shall constitute an acceptance of work not done in accordance with this specification, or relieve the Contractor of liability with respect to any expressed warranties or guarantees or responsibility for faulty materials or workmanship.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment related to the Access Control System, and control-station equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Three (3) years from date of Substantial Completion.
- C. The Integrator shall provide all services required to maintain the system in an operational state as specified by the manufacturer for a period of one (1) year after acceptance.
- D. Service response shall be within twenty-four (24) hours of the initial request for service and shall be provided twenty-four (24) hours per day, seven (7) days per week and three hundred sixty-five (365) days per year.
- E. Contractor shall include, as part of this warranty, a program for maintenance for each integrated system.
 - 1. Provide details of coverage, preventive maintenance schedules, exclusions and service rates for all billable time and travel charges.
 - 2. Maintenance shall include two (2) semi-annual inspections and tests to verify the intended operation of the security system(s). System testing shall include but not be limited to the testing of all devices, fault modes and batteries. A detailed test report indicating these results and any corrective measures shall be furnished to the owner.
- F. The Contractor shall provide software and firmware upgrades as required and available to the Owner.
- G. Submit manufacturer's standard warranties.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL NETWORK MANAGED SYSTEM

A. Selected Manufacturer:

1. The selected manufacturer shall be **Paxton Access Ltd. Greenville, SC**. Other manufacturers will be considered, providing equipment meets or exceeds the quality and functionality specified.
2. The access system must be compatible with Ellington Schools current Paxton access system.
3. The selected model shall be Paxton Net2 Plus and Net2 Entry.
4. Managed software shall be loaded and configured onto the video surveillance server specified within Division 28 Section “Video Surveillance”.
5. Certifications: UL 294 listed, ISO 9000 listed.

B. Net2 Tender - General System Requirements Overview :

1. The access control system will control the movement of users through access points. Users will be identified at access points by presenting a token to a reader.
2. Users are identified at access points by presenting a token to a reader. Alternatively, PINs or codes can be used by entering a unique number into a keypad. If biometric readers are used, then users are identified by a physical property that is unique to them.
3. The access control system will be administered using a PC.
4. The access control software must have a Client/Server structure to facilitate operation on multiple PCs.
5. Equipment used must covered by a manufacturers guarantee against electrical failure for a minimum of 5 years.
6. The access control system should be capable of supporting up to 50,000 users.

C. General system requirements – PC / Server

1. The server is a PC with a current Microsoft Windows operating system.
2. Server requirements:
 - a. Current and detailed hardware requirements to run a Net2 server can be found at <http://paxton.info/720>.
 - b. Typically, Net2 server software is compatible with current Microsoft Windows desktop operating systems running on a desktop PC with current (typically less than one year old) hardware.
 - c. A modern Windows server operating system may be used, but responsibility is placed on the end user for configuration and maintenance of such a device, due to the extra settings and complexity these have. Both desktop and server operating systems should be updated with the latest service packs and updates available from Microsoft.
3. Client:
 - a. There should be no limit to the number of PCs that can run the client software. Additional software licences shall not be required to install the client software
 - b. PCs running the client software should be connected to the server PC via TCP/IP LAN/WAN/VPN etc. The system to be capable of supporting at least 5 simultaneous clients.
 - c. Client PC requirements:
 - 1) Current and detailed hardware requirements to run a Net2 client can be found at <http://paxton.info/720>.

- 2) Typically, Net2 client software is compatible with current Microsoft Windows desktop operating systems running on a desktop PC with current (typically less than one year old) hardware.
 - 3) Desktop operating systems should be updated with the latest service packs and updated available from Microsoft.
4. Web browser and iPhone administration
 - a. Available should be a range of services that use the internet to provide additional features for your access control system. Secure web server and interface software allow operators to monitor and administer a system from any computer with internet access throughout the world for central administration.
 - a. iPhone applications should also be available for operators to perform active functions: Roll Call, Timesheet, Open Door, Reports and Users
- D. General system requirements - Control units
1. The system is to comprise single door control units. This ensures maximum system resilience, through fully distributed intelligence.
 2. Each single door control unit should be capable of supporting 2 readers and 2 keypads for card plus PIN on both sides of the access point.
 3. No additional power supply unit should be necessary at the access point to power readers, exit buttons and typical door locks..
 4. Control units must be able to 'make their decisions locally'. In the event of communications with the server PC being interrupted the system can continue to operate as normal. This maximizes system resilience and flexibility.
 5. Control units should be fitted with fault finding LEDs to enable quick and easy maintenance and fault diagnosis.
 6. Control units must be fitted with FLASH memory enabling high speed firmware upgrades over the network.
 7. To ensure fast, accurate reporting and responsive administration, control units should be capable of communicating with the PC at 115k BAUD (duplex) or plug directly into a TCP/IP network.
 8. The control units should support 10,000/50,000 unique card IDs.
 9. The control units must retain event data when there is no connection to the Server PC. The buffer should retain at least 2,000 events per door.
 10. The control unit must retain its settings in the event of a total power failure. These settings should be maintained for a minimum of 1/28 days before data is lost. .
 11. Control units should be able to automatically unlock the door during specified time periods.
 12. Must be easily configurable to work with wide range of 3rd party reader types.
- E. Control units power supplies and housings
1. It should be possible to power the control unit and associated locking hardware using a POE (802.3af - 802.3at type 1) or POE+ (PoE+ 802.3at type 2) power supply from a single RJ45 connection to a POE/POE+ enabled data network.
 2. It should be possible to power the control unit and associated locking hardware using a 2A 12V DC power supply.
 3. The required power supplies should be housed in either plastic or steel cabinets, and incorporate a tamper switch.
 4. Space must also be provided for a backup battery to supply power for an extended period in event of power failure (Minimum 7 Ah), unless using POE/POE+ where it is assumed a UPS will be used to provide backup power.
 5. Mains failure must be reported to the access control system.

- F. All-in-one Battery powered locks
1. For internal doors, in order to permit easy and quick installation, all-in-one battery powered door locks shall be used.
 2. These door locks shall communicate events wirelessly with the server in real time and this wireless communication must be secure (minimum AES128bit data encryption).
 3. Wireless communication to the server shall be via wireless bridges connected to the server PC either to a USB port or to bridges connected directly to a TCP/IP network. All TCP/IP nodes shall be capable of being detected using DHCP, and then assigned fixed IP addresses.
 4. These door locks should be able to used alongside hard-wired systems and administered via the same software.
 5. There should utilise a Euro Lockcase with or without key override. The handles will also attach to a 8mm spindle, where anti-ligature or custom handle sets can be fitted.
 6. Battery life shall be up to 60,000 operations
- G. General system requirements - Desktop reader
1. A desktop reader must be included for token administration at server/client or both. The desktop reader should connect to the PC via the USB port, and have status LED's.
 2. No additional software shall be required.
- H. General system requirements – Tokens
1. The access control system should store a unique 8 digit user number.
 2. In order to ensure maximum security, tokens must only transmit their number after encrypted passwords have been exchanged between token and reader. Low security protocols such as EM4100 should not be used.
- I. General system requirements – Communications
1. TCP/IP to RS485 converter
 - a. The control units should have a built in TCP/IP Ethernet connection along with an RS485 connection, allowing direct connection to the LAN, connection to other controllers via RS485 or a combination.
 - b. The system must be capable of managing up to at least 200/IP TCP remote interfaces.
 - c. The 485 TCP/IP Ethernet interface should be capable of auto-negotiating speed and duplex up to 100mbps/full duplex.
 - a. The system must be able to support multiple TCP/IP converters on the same system and in conjunction with any other style of converter installed.
 2. Wireless Networked
 - a. In order to permit easy and quick installation, especially in environments where cabling would be difficult, door controllers shall communicate wirelessly with the server.
 - b. Wireless communication must be secure (minimum AES128bit data encryption).
 - c. Communication to the server shall be via wireless bridges connected to the server PC either through a USB port or to bridges connected directly to a TCP/IP network.
 - d. All TCP/IP nodes shall be detected using DHCP, and then assigned fixed IP addresses.
 - e. Wireless networked controllers should be able to used alongside hard wired systems and administered via the same software.
- J. General system requirements – Cabling

1. Control unit to control unit
 - a. Category 6 cable consisting of 4 twisted pairs.
 - b. 4 cores are used for data. The screen wires or remaining 4 cores are to be used as a screen to protect against electrical noise.
 - c. The maximum length of the data line should be up to 100m, without the use of a RS485 repeater. An RS485 repeater device must be available for this use should the cable distance require it.
 2. Control unit to reader
 - a. The Access control readers should come with 5m of included cable. Where extensions are required, 10 core screened cable - Common Reference (CR) 9540 is to be used.
 - b. Length of allowable cable extensions from control unit to reader should be up to 100m.
- K. General system requirements – Software
1. The access control software should use a familiar style user interface, preferably similar to Windows Outlook, enabling intuitive use. The software must also be available in multiple languages to suit the installation.
 2. Database
 - a. A SQL server database is used for the storage of user data and events.
 - b. The software should be capable of importing and exporting user data in .vcf, .csv or .txt formats.
 3. Client/Server structure
 - a. The system should support multiple clients, without extra licence charges being levied.
 4. Access permissions
 - a. Access levels should be used to administer the control of who is allowed through which access points and what times they are allowed through on a minute by minute basis. This ensures optimum flexibility.
 - b. The access control system should support a minimum of 250 such access levels. The system should be able to cope with giving alternative access permissions to some or all staff during bank holidays
 5. Reporting
 - a. User and system events should be shown in real time.
 - b. Filtering options to select all events, access events, alarm events and system events during customised time periods.
 - c. The software must have the ability for the user to configure their own custom reports. Reports should allow selection of date, time, users or user groups and access points. The reports should be configured within the access control user software and not a 3rd party application. A simple wizard should used to configure reports to make configuring and saving reports as simple as possible.
 6. Users
 - a. The system should be capable of supporting up to 50,000 unique card ID's.
 - b. Users must be able to have as many active tokens as required.
 - c. User tokens should be able to be designated as lost.
 - d. The system should be capable of setting a valid date range for user. Outside this date range any cards for that user will be invalid.
 - e. The system should have user definable fields that can be tailored by the system administrator to store address or other relevant information.
 7. Departments

-
- a. Users can be grouped into departments. Departments can be used when generating event reports and setting access permissions.
 - 8. Operators
 - a. Any user may be given operator rights allowing them to log onto the software and administer the system.
 - b. The software should support at least 50 operators.
 - a. The system should allow the restriction of operator privileges in certain areas of the software.
 - 9. Access control alarms
 - a. The following alarms must be handled by the access control system; door forced open, door left open, power supply mains failure, control unit housing tamper.
 - b. Each alarm event is reported in the event log. Alarm events can be acknowledged by an authorised operator.
 - c. In addition, alarm reporting via other mediums, such as SMS or Email, should be supported. An alarm sounder should be generated local to sensitive access points. The exact nature of the sound and time delay before sounding is configurable for each type of alarm and each door.
 - L. Specific system requirements - Readers
 - 1. Proximity reader
 - a. Reader is available in 3 sizes.
 - b. Reader fascias should be interchangeable for aesthetic flexibility.
 - c. An additional attachment should allow a reader to be mounted on a standard UK back box.
 - d. Reader should be rated to IPX7 suitable for external and internal use.
 - e. Electronics should be completely encapsulated in a watertight potting compound.
 - f. Reader should be capable of operating within the temperature range -35°C to 66°C.
 - g. Dimensions (mm)
 - 1) P38 - 38w x 78h x 12.5d
 - 2) P50 - 50w x 100h x 15d
 - 3) P75 - 75w x 143h x 16d
 - 2. Proximity KP series keypad
 - a. Reader combines both PROXIMITY functionality and keypad functionality in one unit.
 - b. Reader is available in 2 sizes.
 - c. Reader bezel is removable.
 - d. Additional coloured bezels are available (Grey, Silver, Navy Blue, Graphite Black, Metallic White).
 - e. Keypad buttons are backlit.
 - f. An additional attachment allows the KP75 reader to be mounted on a standard UK back box.
 - g. Reader is rated to IPX7 suitable for external and internal use.
 - h. Electronics are encapsulated in a watertight potting compound.
 - i. Reader is capable of reading passive Hitag2 proximity tokens.
 - j. Reader is capable of operating within the temperature range -35°C to 66°C.
 - 1) Dimensions (mm)
 - 2) KP50 - 50w x 100h x 15d
 - 3) KP75 - 75w x 143h x 16d
 - 3. Architectural reader
 - a. Designer reader to match the interior of buildings.
 - b. 3 standard inserts available.
-

- c. 3 bezel styles available.
 - d. Drawing provided to allow for custom inserts.
 - e. Reader capable of operating within the temperature range -20°C to 55°C.
 - 1) Dimensions (mm) 70w x 110h x 32d
 - 4. Long range reader
 - a. Integral hands free interface.
 - b. Read range max 5m with hands free tokens.
 - c. Bright LED display is visible even in sunlight.
 - d. Robust casing and easy mounting.
 - e. IPX7 rated suitable for external use.
 - f. Reader capable of operating within the temperature range -20°C to 55°C.
 - 1) Dimensions (mm) 220w x 220h x 120d
 - 5. GSM Caller ID reader
 - a. It should be possible to programme a user's telephone number into the access control software to allow this to be used as a means of identification. By using a GSM device with a SIM card, it should be possible for a user to call the device which in turn recognises the user via Caller ID technology. By wiring this device to the access control unit, it should be possible to gain entry by simply calling the reader.
 - 6. Hands free keyfob or keycard
 - a. Where hands free is required, active hands free fobs or keycards must be used. Batteries should last 5 years and be replaceable. The fob/keycard should work as a standard passive token with non-hands free readers. The keycard should include buttons for activating a control unit directly from at least 5m away.
- M. Specific system requirements – Features
- 1. Security Lockdown
 - a. Lockdown is the facility to secure the site through a single action by disabling access through selected doors. This includes disabling exit buttons and relocking doors held open by time zones. Only users that are specified as being exempt will retain their normal access rights to all doors, including those that are part of the lockdown.
 - 2. Anti-passback - Timed
 - a. The access control system should be capable of denying a user access through the same access point within a specified time period. This prevents the same user's card being handed back to an unauthorised user and used by them.
 - b. It must be possible to exclude certain users from obeying anti-passback rules.
 - 3. Anti-passback - logical
 - a. The access control system should be able to monitor the movement of users throughout a building and only allow them to make 'valid' access transactions through specified doors. An example of an invalid transaction would be a user trying to enter an area that the system knows they are already in. For example a user presents their token and gains access to an area. The system will not allow that card to gain entry into that same area until the user has left that area. This prevents people passing back their card for someone else to gain unauthorised entry to an area. Readers are required on both sides of any access points that are to obey logical anti-passback rules. It is possible to exclude certain users from obeying anti-passback rules.
 - b.
 - 4. Time and attendance

- a. The access control system must include the facility for monitoring time and attendance of staff. This will require the use of dedicated 'clocking in' and 'clocking out' readers. The system should be capable of operating with multiple 'clocking in' and 'clocking out' readers.
 - b. The time and attendance module should be able to cope with different hourly rates for staff and overtime rates such as 'time and a half'.
 - c. The time and attendance module should produce reports showing hours worked for users and departments over different date ranges.
5. Roll call/muster
- a. The access control system must be able to generate a roll call report. This roll call report can be generated manually using the software or automatically via a direct input from the fire alarm system.
 - b. The roll call report should document User name, Department, Last known location, time of last access transaction and their status i.e. 'Safe' or 'Missing'.
 - c. Any reader on the system should be able to be nominated as a muster reader. Users that present their token to a muster reader after a roll call report has been generated are marked as 'Safe'.
 - d. To use the roll call facility the system must be split into 'areas'.
6. Site graphics
- a. The access control system should allow for multiple site graphics to be imported in either jpg or bmp format. The site graphics should show the live status of doors including door open/closed, valid token, invalid token and alarm conditions.
 - b. In the event of an alarm the site graphic should pan to the appropriate part of a site graphic.
 - c. If IP cameras are used then these should be displayed on the site graphics.
7. Areas
- a. The access control system should have the ability to group doors together into defined 'areas'. Once the system is split into areas a user can be given access into an area which will automatically validate them through a number of doors.
 - b. It is possible to have a number of areas collected together within an 'area group'. An example of an area group would be 'Main building'. The Main building area group might encompass the areas Reception, Factory and Canteen
8. Card printing
- a. The access control system should have the ability to print cards using a standard Windows card printer. The card designer program should allow unlimited configurations, with multiple templates saved for each user group. The ability to import company logos and background images, overlay watermarks, static text fields and layers are all required components.
- N. Specific system requirements - Integration
1. Intruder alarm
 - a. The access control system should integrate with a wide range of 3rd party intruder alarm system. Integration can be achieved by using an intruder alarm momentary keyswitch input and status output. The access control software should distinguish between users who can arm or disarm the intruder alarm system. The system must deny access to unauthorised users if the alarm is set.
 - b. The system must have the ability to have multiple alarm setting and un-setting points and different alarm zones if required. No additional charge should be made for this feature.
 2. IP cameras

- a. The access control system is able to display moving images from any IP cameras on the local or wide area network.
 - b. Links to IP cameras are able to be placed in the relevant positions within any site graphics used.
- O. Specific system requirements - Remote sites
- 1. Number of remote sites
 - a. The system is capable of running up to 200 remote sites at one time.
 - 2. TCP/IP
 - a. Where a Wide Area Network is in place, remote sites can be administered centrally. The remote sites have a TCP/IP to RS485 converter sitting on the WAN and door control units connected via a dedicated data line.
 - b. Provided that there is a permanent WAN connection the functionality of the system remains completely unchanged. Access points are controlled in the same way as they would be on the local site.
 - 3. Door Entry System
 - a. Door Entry is a system that works standalone or alongside Paxton's Net2 access control, combining door entry with key features of Net2.
 - b. A visitor initiates a video & audio call via the bell button on the external panel. Visitor access can be granted via a push button on the monitor. When connected to Net2, access to the building can be gained by using a PIN, Code and/or proximity token.
 - c. To build the door entry system, you simply require 3 x components. The panel, the monitor and door controller. For an efficient install, the connections for the panels, monitors and door controller should be a single RJ45 connection which self detect & configure on power up, utilising IPv6.
 - d. You can have up to 100 x Panels & 1,000's of monitors on any single network
 - e. The Door Entry system should support SIP (Session Initiation Protocol) allowing for VOIP communication to other SIP enabled devices (i.e. SIP servers, smart phones, tablets and softconsoles)
 - 4. Door Entry Vandal Resistant Panel
 - a. The Vandal Resistant Panel should be made from corrosion resistant marine grade stainless steel and has an IP55 rating, to meet the most demanding environments.
 - b. A toughened polycarbonate screen to withstand even the harshest treatment with an impact resistance rating of IK09.
 - c. Installation - VR Panel components simply interconnect using Cat5 or standard RJ45 terminated patch cables. The VR Panel should utilise existing network infrastructure for simple installation. PoE technology runs power and data along the same cable to avoid the need for separate power supplies.
 - d. The panel should come in three variants; surface mount, flush mount and rain hood, allowing for a variety of jobs.
 - e. The panel should have an all-in-one design, to include; high quality colour camera, keypad and built in proximity reader.
 - f. The Panel should be SIP (Session Initiation Protocol) enabled.
 - 5. Door Entry Monitor
 - a. Allows a person inside a building to identify a visitor before they are granted entry. Upon recognition of the visitor via high quality audio and colour video monitor, the person can grant or deny access as appropriate via their touchscreen monitor and opening the exterior door.
 - b. The wall mounted or desk mounted Monitor shall incorporate an intuitive colour touchscreen visual display, where you can access features like; volume controls,

- multiple language options, text size, camera display, help menu and naming of the monitor, of which will be displayed at the panel.
- c. The monitor should also include a Do Not Disturb function, allowing privacy to the occupant. When the monitor is in DND the panel will still call as normal, so externally the caller will have no indication if the occupant is in occupancy or not.
- d. The internal monitor can be used via either the handset for private calls or in hands free mode.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Device Locations

1. All device locations are to be field verified with the Owner prior to start of project. Architectural drawings are for approximation purposes only. Additional charges will not be allowed for outlet installation in areas not reviewed or approved by the Owner.

B. 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.

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

3.2 WIRING

A. Control and low-voltage cabling has been provided and installed by others and is referenced within the Drawings. This cabling has been roughed in and is within the junction boxes adjacent to each door requiring access controls. Final terminations to all devices are required by the bidding integrator of this section.

B. Final connections at both the device end and data closet and including any additional cable necessary for these connections is required as part of this bid.

3.3 INSTALLATION

A. Install all devices and infrared illuminators level and plumb.

B. Install power supplies and other auxiliary components at control stations unless otherwise indicated.

C. Identify system components, wiring, cabling, and terminals according to ANSI/EIA/TIA standards.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: The Contractor shall engage a qualified testing agency to perform tests and inspections with the Owner and appointed project manager.
- 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. 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.
 - 3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least fourteen (14) days. Provide a minimum of ten (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.
- E. Access Control System shall be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) 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 access control devices.
 - 3. Provide a written report of adjustments and recommendations.

3.6 CLEANING

- A. Remove rubbish and debris: Installation contractor is not allowed you use the onsite dumpster and is responsible to discard their own debris off site.
- B. Clean installed items using methods and materials recommended in writing by manufacturer.

3.7 DEMONSTRATION – TRAINING

- A. Bidding contractor shall engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain Access Control system.
- B. Sixteen (16) hours of training shall be included as part of this specification.

END OF SECTION 281300

SECTION 281600 - INTRUSION DETECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Division 01 Section 019113 General Commissioning Requirements.
- C. Related Drawings
 - 1. T"x" Technology Plans
- D. Related Sections:
 - 1. The devices within this section must fully integrate with the existing intrusion detection system within the existing High School.

1.2 SUMMARY

- A. The scope of work required as part of this project shall include a temporary service feed from the telecommunication distribution area that is co-located within room T106 to a pre-existing intrusion detection system that is located in the existing High School. This temporary cabling shall be replaced with a permanent cabling during the phased renovations of the existing High School.
- B. Section Includes:
 - 1. Control Panel
 - 2. Motion Sensors
 - 3. Door Contacts
 - 4. Intrusion detection devices
 - 5. Duress/Panic buttons
- C. These specifications contain the functional and operational requirements for an integrated intrusion alarm system employing motion detection devices and door contacts as the primary means of intrusion detection for selected interior protection. This procurement shall include all the equipment required at various facilities as shown on the Drawings.
- D. Responsibility for the integrated security systems and equipment is specified in the following sections and shall be coordinated with the finish door hardware and Fire Alarm sections.
- E. The intrusion system is intended to provide protection of selected facilities against intrusion and for the detecting or discouraging of burglary or vandalism during the hours the facilities are

unoccupied and report signal to the Central Station.

- F. General: Provide and install an integrated security system and all devices, terminations, associated supporting devices, configuration of system, testing and training in accordance with this Bid package to provide a complete and functional system.
- G. The cabling provided and installed by other trades is described within the construction bid document and referenced on the drawings associated with this bid package. All other cabling required to provide a complete and functional system shall be furnished and installed by the Contractor awarded this portion of work.
- H. The proposed system shall interface with the existing intrusion detection system.
- I. This specification is used to identify the requirements for integrated Burglar entry systems encompassing door contacts and motion detectors.
- J. Responsibility for the integrated security systems and equipment is specified in the following sections and shall be coordinated with the Finish Hardware and Fire Alarm sections of the Phase I Construction.
- K. It is the intent of these specifications to procure a fully acceptable, effective and reliable integrated security system. Refer to the Drawings for division of responsibility. These specifications recognize the importance of complete system operation and are not limited to specifying of equipment only. The following are also required from the selected bidder:
 - 1. Proven experience in the security business.
 - 2. Prompt delivery and professional installation including service of equipment as specified.
 - 3. Bidder must provide, for objective evaluation, references, which clearly state and show the effectiveness of proposed equipment and services.
 - 4. Used products will not be acceptable. Manufacturer must satisfactorily demonstrate that he has supplied and will continue to supply products to avoid the obsolescence of equipment installed in the building.
 - 5. All equipment shall be fully guaranteed for twelve (12) months. This guarantee shall become effective from the day of installation completion. When in normal operation, if the equipment is found to be below the manufacturer's specification, repair and replacement of equipment shall be provided. Repairs shall be started within twenty-four (24) hours and completed without delay. Installation contractor shall either stock spares or be capable of obtaining all required replacement parts within twenty-four (24) hours.
 - 6. Extended warranty terms shall be provided by the installing security system integrator at the time of bid.

1.3 SYSTEM DESCRIPTION

- A. The system shall be a Burglary/Access Control/CCTV Switching System that includes the following capabilities:
 - 1. Listed for UL Commercial Burglary VISTA-128BP - 1 Detection and Alarm
 - 2. Supports up to 128 zones.
 - 3. Supports up to eight (8) separate partitions.
 - 4. Supports up to 150 users.
 - 5. Provides integrated security, access control, and CCTV switching capability.

6. Provides supervision of peripheral devices.
7. Supports up to 96 optional relay outputs.
8. Supports long-range radio (LRR) communication.
9. Provides scheduling capability to allow for automated operations.
10. Supports up to eight (8) alphanumeric paging devices.
11. Supports panel linking.
12. Supports alarm reporting via Internet.
13. Interfaces with automation software.
14. Capable of being installed using existing wiring.

1.4 APPLICABLE STANDARDS

- A. All of the work within the scope of this bid shall be performed in accordance with the applicable state, county and city laws and ordinances. The bidder shall be able to obtain all permits and licenses as required in addition to being a licensed contractor. All materials, supplies and equipment being furnished shall be installed in accordance with the latest version of the applicable standards of:
1. OSHA
 2. Uniform Building Code
 3. Americans with Disabilities Act (ADA)
 4. Components of the system shall be of the type approved by Safety and Regulatory Agencies including:
 - a. Underwriters' Laboratories (UL), Inc.
 - b. Federal Communications Commission (FCC).
 - c. Agency approvals and UL Listing declare the system's design, components, and installation shall meet the highest standards.
 - d. System installation shall comply with UL 681 and UL 611.
 5. Alarm detection systems intended for UL certified fire alarm reporting shall meet the requirements of UL Standard 985, NFPA Standard 72 Chapter 2.
 6. The equipment shall comply with Part 68 of the FCC Telephone Requirements Rules.
 7. All circuits and equipment shall be installed and protected according to the National Electric Code and any applicable local requirements.

1.5 DEFINITIONS

- A. LCD: Liquid-crystal display.
- B. LED: Light-emitting diode.
- C. PIR: Passive infrared.
- D. RFI: Radio-frequency interference.
- E. Protected or Protection Zone: A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.

1.6 SUBMITTALS

- A. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
 - 1. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers, networks, and control interface devices and media to be used. Describe characteristics of network and other data communication lines.
 - 2. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.
 - 3. Device Address List: Coordinate with final system programming.
 - 4. 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.
 - 5. 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 not acceptable.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Data for each type of product, including features and operating sequences, both automatic and manual.
 - 2. Central-station control-unit hardware and software data.
- F. Warranty: Special warranty specified in this Section.
- G. In the event that the installation contractor does not furnish or does not supply sufficient documentation, the owner has the right to engage a separate contractor to attain any or all required documentation. All costs related with this event shall result in a back charge to the installation vendor via a change order.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. An employer of workers, at least one of whom is a technician certified by the National

2. Burglar & Fire Alarm Association.
 2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 3. A copy of the Contractors Certified Installers Certificate shall be furnished with bid response.
- B. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and/or Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- 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. FMG Compliance: FMG-approved and -labeled intrusion detection devices and equipment.
- E. Comply with NFPA 70.
- F. Electrical Power
1. Normal System Power Supply: 120V, 60Hz, through a locked disconnect device and an isolation transformer in a central-station control unit. Central-station control unit shall supply power to all components connected to it unless otherwise indicated.
 2. Power Continuity for Central-Station Control Units: Batteries in power supplies of the central-station control unit and individual system components shall maintain continuous system operation during outages of both the normal and backup ac system supply.
 - a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal ten (10) year life expectancy. Capacity adequate to operate portion of system served, including audible trouble signal devices for up to four (4) hours and audible and visual alarm devices under alarm condition for an additional ten (10) minutes.
 - b. Battery Charger: Solid-state fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within twenty-four (24) hours.
- B. Annunciation: Indicate a change in system condition and switching of system or component to backup power.
- 1.8 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: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturer:

1. The systems specified is based on the following manufacturer which is standardized within the town district:
2. Manufacturer: **Honeywell Vista 128BP**
3. System performance
 - a. Control Panel - The control panel shall be an eight (8)-partition, UL commercial burglary control panel that supports up to 128 zones using basic hardwired, polling loop, and wireless zones. It shall also provide supervision of the bell output, RF receivers, and relay modules. In addition, the control shall provide the ability to schedule time-driven events, and allow certain operations to be automated by pressing a single button. The system shall be capable of interfacing with an ECP long range radio (LRR) unit that can send Contact ID messages, and alphanumeric paging devices. The control shall provide integrated access control and CCTV-switching capability.
 - 1) Basic Hardwired Zones - The control shall provide nine (9) style-B hardwire zones with the following characteristics:
 - a) EOLR supervision (optional for zones 2-8): Shall support N.O. or N.C. sensors (EOLR supervision required for UL installations).
 - b) Individually assignable to one of eight (8) partitions.
 - c) Supports up to 16 two-wire smoke detectors on one selected zone.
 - d) Supports four-wire smoke or heat detectors on any zone (power to four-wire smoke detectors must be supervised with an EOL device).
 - e) Supports up to 50 two-wire latching glass break detectors on one selected zone.
 - b. Expansion Zones
 - 1) Polling Loop Expansion – The control shall support up to 119 additional hardwire zones using a built-in two-wire polling (multiplex) loop interface. The polling loop shall provide power and data to remote point modules, and constantly monitor the status of all zones on the loop. Maximum current draw shall not exceed 128 mA. The polling loop zones shall have the following characteristics:
 - a) Interface with RPM (Remote Point Module) devices that provide Class B, Style Y (e.g., 4208U/4208SN) or a combination of Class B, Style Y, and Class A, Style Z (e.g., 4208SNF) zones.
 - b) Individually assignable to one of eight (8) partitions.
 - c) Supervised by the control panel.
 - d) A 12,000 ft (3658 m) wire run capability without using shielded cable.
 - e) Each RPM (Remote Point Module) enclosure shall be tamper protected.
 - c. Partitions – The control shall provide the ability to operate eight (8) separate areas, each functioning as if it had its own control. Partitioning features shall include:
 - 1) A Common Lobby partition (1-8), which can be programmed to perform the following functions:
 - a) Arms automatically when the last partition that shares the common lobby is armed.

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- b) Disarms when the first partition that shares the common lobby is disarmed.
 - 2) A Master partition (9), used strictly to assign keypads for the purpose of viewing the status of all eight (8) partitions at the same time (master keypads).
 - 3) Assignable by zone.
 - 4) Assignable by keypad.
 - 5) Assignable by relay to one or all eight (8) partitions.
 - 6) Ability to display fire and/or burglary and panic and/or trouble conditions at all other partitions' keypads (selectable option).
 - 7) Certain system options selectable by partition, such as entry/exit delay and subscriber account number.
- d. User Codes – The control shall accommodate 150 user codes, all of which can operate any or all partitions. Certain characteristics must be assignable to each user code, as follows:
- 1) Authority level (Master, Manager, or several other Operator levels). Each User Code (other than the installer code) shall be capable of being assigned the same or a different level of authority for each partition that it will operate.
 - 2) Opening/Closing central station reporting option.
 - 3) Specific partitions that the code can operate.
 - 4) Global arming capability (ability to arm all partitions the code has access to in one command).
 - 5) Use of an RF (button) to arm and disarm the system (RF key must first be enrolled into the system).
- e. Peripheral Devices – The control shall support up to 30 addressable ECP devices, which can be any combination of keypads, RF receivers, relay modules, annunciator modules, and interactive phone modules. Peripheral devices have the following characteristics:
- a. Each device has the device's instructions.
- 1) Each device set to an individual address according to the device's instructions.
 - 2) Each device enabled in system programming.
 - 3) Each device's address shall be supervisable (via a programming option).
- f. Keypad/Annunciator – The control shall accommodate up to 16 keypads or six (6) touch-screen (i.e., advanced user interface) keypads. The keypads shall be capable of the following:
- 1) Performing all system arming functions.
 - 2) Being assigned to any partition.
 - 3) Providing four programmable single-button function keys, which can be used for:
 - a) Panic Functions –activated by wired and wireless keypads; reported separately by partition.
 - b) Keypad Macros –32 keypad macro commands per system (each macro is a series of keypad commands). Assignable to the A, B, C, and D keys by partition.
- g. Vista Interactive Phone Module – The control shall support the ADEMCO 4285/4286 VIP Modules, which permit access to the security system in order to perform the following functions:
- 1) Obtain system status information. Arm and disarm the security system. Control relays.

- 2) Arm and disarm the security system.
- 3) Control relays.
- h. LED Annunciator – The control shall support the ADEMCO FSA-8 and FSA-24 annunciators, which are capable of:
 - 1) Visually identifying a zone or point that is in alarm or trouble.
 - 2) Programmable for system silence/reset.
 - 3) Up to 96 LEDs may be used in one system.
 - 4) A total of four (4) FSA-24 or 12 FSA-8 annunciators may be used in one system.
 - 5) An optional keyswitch, FSAKSM module, shall be available for UL listed Silence and Reset capability.
- i. Voltage Triggers – The system shall provide voltage triggers, which change state for different conditions. Used with LRR (Long Range Radio) equipment or other devices such as a remote keypad sounder, keyswitch ARMED and READY LEDs, or a printer to print the system's event log.
- j. Event Log – The System shall maintain a log of different event types (enabled in programming). The event log shall provide the following characteristics:
 - 1) Stores up to 512 events.
 - 2) Viewable at the keypad or through the use of Compass software.
 - 3) Printable on a serial printer using a 4100SM Module including zone alpha descriptors.
 - 4) Stores PassPoint access control events.
 - 5) Sends printed events to up to eight alpha numeric pagers.
- k. Scheduling - Provides the following scheduling capabilities:
 - 1) Open/close schedules (for control of arming/disarming and reporting).
 - 2) Holiday schedules (allows different time windows for open/close schedules).
 - 3) Timed events (for activation of relays, auto-bypassing and un- bypassing, auto-arming and disarming, etc.).
 - 4) Access schedules (for limiting system access to users by time)
 - 5) End User Output Programming Mode (provides 20 timers for relay control).
 - 6) The system shall automatically adjust for daylight savings time.
- l. Communication Features - Supports the following formats and features for the primary and secondary central station receivers:
 - 1) Formats
 - a) ADEMCO Low Speed (Standard or Expanded).
 - b) SESCOA/Radionics.
 - c) ADEMCO Express.
 - d) ADEMCO High Speed.
 - e) ADEMCO Contact ID.
 - 2) Backup reporting – The system shall support backup reporting via the following:
 - a) Secondary phone number.
 - b) ECP long range radio (LRR) interface.
 - c) Option to select long range radio (LRR) or dialup as the primary reporting method (dynamic signaling feature).
 - 3) Internet reporting – The system shall be capable of communicating with the central station via the internet using Alarmnet-i. It shall provide the user with the ability to control the system via a browser interface (i.e., AOL,

- Netscape, Internet Explorer). All packet data transmitted to the monitoring station shall be encrypted with a minimum of 1024 bits of encryption.
- m. Audio Alarm Verification Option - Provides a programmable Audio Alarm Verification (AAV) option that can be used in conjunction with an output relay to permit voice dialog between an operator at the central station and a person at the premises.
 - n. Cross-Zoning Capability - Helps prevent false alarms by preventing a zone from going into alarm unless its cross-zone is also faulted within 5 minutes.
 - o. Pager Interface – The Control Panel shall be capable of sending event information to an alphanumeric pager via a VA-8201 pager interface device.
 - p. Exit Error False Alarm Prevention Feature – The System shall be capable of differentiating between an actual alarm and an alarm caused by leaving an entry/exit door open. If not subsequently disarmed, the control panel shall:
 - 1) Bypass the faulted E/E zone(s) and/or interior zones and arm the system.
 - 2) Generate an Exit Error report by user and by zone so the central station knows it was an exit alarm and who caused it.
 - q. Built-in User's Manual and Descriptor Review - For end-user convenience, the control panel shall contain a built-in User's Manual. It shall include the following capabilities:
 - 1) By depressing any of the function keys on the keypad for five (5) seconds, a brief explanation of that function shall scroll across the alphanumeric display.
 - 2) By depressing the READY key for five (5) seconds, all programmed zone descriptors shall be displayed (one at a time). This feature shall provide a check for installers and ensure all descriptors have been entered properly.
 - r. Programming - The Control shall be capable of being programmed locally or remotely using the ADEMCO Compass Downloader and shall be capable of:
 - 1) Uploading and downloading all programming information at 300 baud.
 - 2) Uploading and displaying firmware revision levels from the control.
 - s. Panel Linking - The Control shall be capable of being networked together with up to eight other controls and being operated by any keypad within the system. It shall provide the ability for users to:
 - 1) Control multiple zones, partitions, and/or buildings from a central location.
 - 2) Check status, arm and disarm any partition from any keypad in the system.
 - 3) Globally arm or disarm partitions based upon user authority.
 - t. Automation Software - The Control shall be capable of interfacing with automation software via an RS232 input on a single partition.

2.2 COMMUNICATION DEVICE

- A. **HONEYWELL #GSMV4G** or equivalent Digital Cellular Communicator for VISTA Control Panels
- B. Features
 - 1. Multi-GSM platform compability —2G, 3G and 4G
 - 2. Automatic selection of the best available GSM network
 - 3. 4G capable using HSPA+ protocol
 - 4. Full Contact ID or ADEMCO® High-Speed Reporting Contact ID reporting using ECP mode with compatible Honeywell control panels or combined with optional dialer capture for non-ECP capable control panels.

5. 256-bit AES Encryption Advanced encryption standard used for secure communications.
6. Upload/Download Available with select Honeywell control panels. Requires Compass version 1.5.8.54a or higher.
7. Integration Quick and easy installation of GSM for VISTA® and LYNX controls.
8. Dynamic Signaling with Certain Honeywell Control Panels Provides management of control panel dialer and digital cellular communicator. Programmable priority and delays determine signal path.
9. Diagnostic LEDs Provide signal strength and status indications.
10. QOS Quality of Service diagnostics via AlarmNet supply vital information including when a message was received, battery voltage, input voltage, signal strength and message path.
11. Web-Based Programming Allows complete interactive programming from AlarmNet Direct. Error! Hyperlink reference not valid.
12. Intelligent Supervision Any message generated serves as a supervision message per optional 24 hour or 30 day intervals. This feature effectively limits required messages to be sent.
13. Remote Services Capability* Optional Honeywell Total Connect™ Remote Services value-added web-based or SMS system control as well as e-mail notification of system events.
14. Two-way Voice Transport GSM voice channel capable to allow two-way voice session in conjunction with an audio verification system (GSMX4G/iGSMV4G/GSMV4G/VISTA-GSM4G).

2.3 DOOR CONTACTS

- A. Compatible with Honeywell.
- B. Flush-Mounted Switched: Unobtrusive and flush with surface of door and window frame.

2.4 MICROWAVE-PIR DUAL TECHNOLOGY MOTION SENSORS

- A. **HONEYWELL #IS2500SN** or equivalent
 1. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within the protected zone(s) and by being insensitive to the general thermal variations.
 2. Wall-Mounting Unit Maximum Detection Range: One hundred twenty-five percent (125%) of indicated distance for an individual unit and shall not be less than 50 feet.

2.5 ALARM KEYPAD CONSOLE

- A. **HONEYWELL #6160** Console

2.6 ENCLOSURE

- A. The Control Panel shall be enclosed in a metal cabinet, suitable for wall mounting. The dimensions shall not exceed 14.5 inches (36.8 cm) in height, 12.5 inches (31.8 cm) in width or 3 inches (7.6 cm) in depth.

2.7 ELECTRICAL POWER REQUIREMENTS

- A. System Power – The Fire and Burglary Alarm System shall operate using standard 120 volts AC, 50/60 Hz power.
 - 1. Control Primary Power – Transformer power shall be 16.5 VAC, 40VA.
 - 2. Backup Battery – A rechargeable 12 VDC, gel type, lead acid backup battery shall be provided. The battery shall be rated between 7 and 34- ampere hours (AH).
 - 3. Alarm Power – Alarm power shall be 12 VDC, 1.7 amps for each bell output
 - 4. Auxiliary Standby Power – Standby power shall be 12 VDC, 750 mA maximum.
 - 5. Fusing – The battery input, auxiliary, and bell outputs shall be protected using PTC circuit breakers. All outputs shall be power limited.

2.8 DURESS / PANIC BUTTONS

- A. Approved Manufacturer:
 - 1. STI – Safety Technology International, Inc. Waterford, MI USA. www.sti-usa.com
 - 2. Or approved equivalent
- B. Product:
 - 1. STI #SS-2001 - #CUSTOM-LBL
 - 2. Label shall be labeled as “EMERGENCY”

2.9 SUBSTITUTIONS

- A. Substitution of any item shall only be permitted when the Owner waives the specification(s) of a particular product(s) in writing, allowing a substitute item to be bid. It shall be the responsibility of the Contractor requesting the substitution that the proposed item is equivalent in each and every way to the originally specified product stated within this bid specification and drawing package and that it is in the best interest of the Owner to use the proposed substitute.

PART 3 - EXECUTION

3.1 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

3.2 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
 - 1. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
 - 2. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- B. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Re-inspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- C. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 SYSTEM INSTALLATION

- A. The System shall be installed and tested in accordance with the Manufacturer's Installation instructions. The following conditions are applicable:
- B. In order to ensure a complete, functional System, for bidding purposes, where information is not available from the Owner upon request, the worst case condition shall be assumed.
- C. Interfaces shall be coordinated with the Owner's representative, where appropriate.
- D. All necessary backboxes, pullboxes, connectors, supports, conduit, cable, and wire shall be furnished and installed to provide a complete and reliable System installation.
- E. All conduit, cable, and wire shall be installed parallel and square with building lines. Conduit fill shall not exceed forty percent (40%). All wires shall be gathered, labeled and tied to create an orderly installation.
- F. Comply with UL 681.

3.4 WIRING INSTALLATION

- A. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- B. Wires and Cables:
 - 1. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
- C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- D. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
- E. Identify components with engraved, laminated-plastic or metal nameplate for central-station control unit and each terminal cabinet, mounted with corrosion-resistant screws.

3.5 GROUNDING

- A. 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.
- B. 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.
- C. Install grounding electrodes of type, size, location, and quantity indicated.

3.6 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 the following field tests and inspections and prepare reports:
 - 1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 2. Operational Tests: Schedule tests after pretesting has been successfully completed. Test all modes of system operation and intrusion detection at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
 - 3. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:
 - a. Verify the absence of unwanted voltages between circuit conductors and ground.

- b. Test all conductors for short circuits using an insulation-testing device.
 - c. With each circuit pair, short circuit at the far end of circuit and measure circuit resistance with an ohmmeter. Record circuit resistance of each circuit on Record Drawings.
 - d. Verify that each controller is in normal condition as detailed in manufacturer's operation and maintenance manual.
 - e. Verify that transient surge-protection devices are installed according to manufacturer's written instructions.
 - f. Test each initiating and indicating device for alarm operation and proper response at central-station control unit.
- C. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.
- D. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within twelve (12) months of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 281600

SECTION 282300 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Video Surveillance Cameras
- B. Video Surveillance Management Software
- C. Network Video Server
- D. Network Storage Device
- E. Monitor

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Drawings:
 - 1. "T" Technology Plans
- C. Related Section:
 - 1. Division 01 Section "Summary of Work" for phasing schedule.
 - 2. Division 28 Section "Access Controls".
 - 3. Division 28 Section "Intrusion Detection".

1.3 SUMMARY

- A. This Video surveillance system described within this specification shall be fully integrated with the monitoring and access control systems. The access control system shall be an S2 platform. Complete interface, including user access and browser interface to this S2 platform is the responsibility of the bidding contractor of this section.
- B. All installation of each product specified within this document, peripheral devices, required licensing and configurations are required as part of this specification to establish a coherent, functional system as described within this bid package.
- C. Data Cabling: Category 6 Plenum rated cabling has been furnished and installed by other trades and is not required as part of this bid specification.
- D. System Functionality Overview:

1. System shall provide high-quality delivery and processing of IP-based video and control data using standard Ethernet-based networks.
2. System shall have seamless integration of all video surveillance and control functions.
3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
4. System design shall include all necessary compression software for high-performance, dual-stream, Motion JPEG and H.264 video.
5. All camera signals shall be compressed to H.264, encoded, and delivered onto the network for processing and control by the IP video-management software.
6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
7. **The Camera's recorded images shall include masking of the unwanted areas within each camera view to minimize storage space. These recorded images shall be defined with the Owner and technology consultant.**
8. Configuration of the Video Server to utilize two (2) Ethernet connections and Network Interface cards; one (1) for incoming video and recording and one (1) to send recorded video to the storage device.
9. Video management software shall be configured for the following.
 - a. Recorded Video Compression Rate: H.264
 - b. Frame Recorded Per Second: Twelve (12).
 - c. Resolution should be set at the highest obtainable from each camera specified.
 - d. Stored data shall be saved for thirty (30) calendar days.
 - e. Interior cameras shall record twenty-four (24) hours per day.
 - f. Exterior cameras shall record twenty-four (24) hours per day.
 - g. Each camera "Field of View" shall be set up with the assistance of the Owner and/or the Technology consultant.

- E. 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's entry connection to components.

1.4 SYSTEM CONFIGURATIONS – OVERVIEW

- A. All system configuration(s) shall be included to attain a fully functional system and shall be within the Scope of work of the awarded Contractor of this section. This configuration shall include but not be limited to the following:
1. Configuration of all cameras to be managed via the ExacqVision Professional Video Management software.
 2. Configuration of Video Surveillance Server to view/record/access all cameras.
 3. Configuration of video storage devices with the server.
 4. Configuration of the Video Server.
 5. Configuration of LAN switches – Active Electronics, as related to the systems specified within this document. Including VLANS and IP addressing shall be as indicated by the Owner.
 6. Configuration of the ExacqVision Professional software to:
 - a. Allow complete interface between both platforms
 - b. Allow Paxton to access and view all video surveillance cameras.

- c. Allow access and controlled network management system with Web and Internet access of the Video Surveillance system.

1.5 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman – type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.
- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. WAN: Wide area network.
- I. H.264: Standard for Video Compression
- J. M-JPEG: Motion JPEG
- K. NTSC: National Television System Committee.
- L. PC: Personal computer.
- M. PTZ: Pan-Tilt-Zoom.
- N. RAID: Redundant array of independent disks.
- O. TCP: Transmission control protocol – connects hosts on the Internet.
- P. UPS: Uninterruptible power supply.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For video surveillance. 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. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.

3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
 4. Wiring Diagrams: For power, signal, and control wiring.
- C. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals.
- F. Warranty: Sample of special warranty.

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.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.
- D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

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. Interior, Controlled Environment: System components installed in temperature-controlled 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 twenty to ninety percent (20-90%) relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
 2. Interior, Uncontrolled Environment: System components installed in non- temperature-controlled 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 twenty to ninety percent (20-90%) relative humidity, noncondensing. Use NEMA 250, Type 3R 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 twenty to ninety percent (20-90%) relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick. Use

- sufficiently rated NEMA 250 enclosures.
4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
 5. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use sufficiently rated NEMA 250 enclosures.
 6. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.9 BIDDING CONTRACTOR QUALIFICATIONS

- A. The Contractor shall be a certified and trained installer of each product specified within this document.
- B. The ExacqVision software vendor shall be a registered dealer, whereby training and certification programs shall qualify the suitability of the installers. The vendor shall provide various levels of training including advanced training (i.e., “Gold” level).

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Three (3) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CAMERAS

- A. Manufacturer: The selected manufacturer shall be SONY Electronics Inc., Park Ridge, NJ www.sony.com/security and Scallop Imaging Boston, MA. Subject to compliance with the indicated camera requirements, any submitted alternate must be a certified camera of the ExacqVision IP Camera Integration list and meet the specifications within this document.
- B. Basis-of-Design Product: **Subject to compliance with the indicated camera requirements**, the following manufacturers are approved alternates:
 1. **Panasonic** Corporation of North America; Panasonic Security Systems.
 2. **IQinVision**, San Juan Capistrano, CA, USA
- C. All associated devices and/or licensing is required to obtain a fully functional system, as mandated by this bid specification, shall be included as part this bid specification.
- D. Licensing
 1. All required licensing shall be included as part of this specification.

E. Camera Locations:

1. All camera locations MUST to be field verified with the Owner prior to start of project. Architectural drawings are for approximation purposes only. Additional charges will not be allowed for installation in areas not reviewed or approved by the Owner.

F. General Requirements:

1. All equipment and materials used shall be standard components that are regularly manufactured and used in the manufacturer's system.
2. All systems and components shall have been thoroughly tested and proven in actual use in the presence of the Owner or technology consultant.
3. All systems and components shall be provided with the availability of a toll-free (U.S.), 24-hour technical assistance program (TAP) from the manufacturer. The TAP shall allow for immediate technical assistance for either the dealer/installer or the end user at no charge for as long as the product is installed.
4. All systems and components shall be provided with a one-day turnaround repair express and 24-hour parts replacement. The repair and parts express shall be guaranteed by the manufacturer on warranty and non-warranty items.

G. Camera Certifications:

1. CE, Class B
2. FCC, Class B
3. UL/cUL Listed
4. C-Tick

H. Camera Warranty

1. Three (3) years, parts and labor

I. INTERIOR FIXED COLOR CAMERA – 1.3 MEGAPIXEL

1. The **SONY #SNC-DH140T** Network HD, mini-dome, 1.3 Megapixel camera has been selected.
2. Integrated Network Camera Specifications:
 - a. The network camera shall offer dual video streams with up to 1.3 megapixel resolution (1280 x 1024) in progressive scan format. The network camera shall be a compact size with a 3 inch class bubble, shall include a compact indoor enclosure, and come with an integrated varifocal 2.8~10 mm lens.
 - b. The network camera shall be capable of firmware upgrades remotely, over the network. In addition, a built-in accessory jack shall provide hardware expansion capabilities for future accessories such as two way audio or hard drive.
 - c. The network camera shall offer a service connector between NTSC and PAL analog video output, operated by a toggle button.
 - d. The network camera shall support two simultaneous, configurable video streams. H.264, MJPEG, and MPEG-4 compression formats shall be available for primary and secondary streams with selectable Unicast and Multicast protocols. The streams shall be configurable in a variety of frame rates and bit rates.
 - e. The network camera shall support industry standard Power over Ethernet (PoE)

- IEEE 802.3af to supply power to the camera over the network.
- f. The network camera shall use a standard Web browser interface for remote administration and configuration of camera parameters. The browser interface shall support multi-screen remote monitoring for up to 16 cameras on the same virtual local area network (VLAN).
- g. The network camera shall support standard IT protocols outlined in section 2.04. In addition, the network camera shall support open architecture best practices with a published API available to third-party network video recording and management systems.
- h. The network camera shall meet or exceed the following design and performance specifications.

J. EXTERIOR FIXED HIGH DEFINITION NETWORK COLOR CAMERA

1. The **SONY #SNC-DH240T With PENDANT WALL MOUNT**, 1080P HD, 3.1 Megapixel camera has been selected.
2. Integrated Network Camera Specifications:
 - a. The network camera shall offer dual video streams with up to 3.1 megapixel resolution (1920x1440) in progressive scan format. Color and day/night models shall be available.
 - b. The network camera shall be capable of firmware upgrades remotely, over the network. In addition, a built-in accessory jack shall provide hardware expansion capabilities for future accessories such as two way audio or hard drive.
 - c. The network camera shall offer a service connector to assist the installer to set field of view and focus the camera.
 - d. The network camera shall provide advanced low-light capabilities for color and day/night models.
 - e. The network camera shall support two simultaneous, configurable video streams. H.264 and JPEG compression formats shall be available for primary and secondary streams with selectable Unicast and Multicast protocols. The streams shall be configurable in a variety of frame rates and bit rates.
 - f. The network camera shall support industry standard Power over Ethernet (PoE) IEEE 802.3af to supply power to the camera over the network. The network camera shall also offer a 24 VAC power input for optional use.
 - g. The network camera shall use a standard Web browser interface for remote administration and configuration of camera parameters including ABF. The browser interface shall support multiscreen remote monitoring for up to sixteen (16) cameras on the same virtual local area network (VLAN).
 - h. The network camera shall support standard IT protocols.
 - i. The network camera shall support open architecture best practices with a published API available to third-party network video recording and management systems.
 - j. The network camera shall meet or exceed the following design and performance specifications.

K. INTERIOR TRUE 180° HIGH DEFINITION NETWORK COLOR CAMERA

1. **Scallop Imaging D7-180, 7 Megapixel 180° Panoramic Color Video Camera**
 - a. Manufacturer: Scallop Imaging, A Division of Tenebraex Corporation 27 Drydock Avenue, Boston, MA 02210, 1-617-849-6400, www.scallopimaging.com
 - b. Description

- 1) The 7 megapixel Digital Window[®] D7-180 video surveillance camera is a 180° panoramic video camera. The imaging task is distributed amongst five micro camera modules. The D7-180 synthesizes five image data streams into (1) 15 fps HD 720p frame that combines a seamless 180° field of view situational awareness view with up to four separate and quickly repositionable detail views. In addition, the camera has a full resolution 7 Megapixel video stream at 1 fps for recording and forensic viewing
- c. General Requirements:
- 1) The camera shall be a network enabled color camera utilizing (5) 1.3Megapixel CMOS image sensors.
 - 2) The camera shall have output a resolution of 1280x1024 pixels per image sensor for a total of 5120x1280 pixels.
 - 3) The camera shall produce panoramic images by synchronizing the 5 image sensors and fusing the output of the image sensors into a stitched 180° field of view.
 - 4) The camera aggregate frame rate across all 5 image sensors shall be 75 frames/sec.
 - 5) The camera shall be H.264 (MPEG4, Part 10) compliant. The camera shall provide six levels of H.264 compression quality selectable by the user for optimal viewing and recording.
 - 6) The camera shall have a horizontal field of view of 180° and a vertical field of view of 48°.
 - 7) The camera shall have multi-streaming capability and shall deliver up to two simultaneous video streams: [1] a high definition 720p (1280x720 pixels) stream where the video frame format is composed of a full 180° situational awareness view resampled to fit into the 720p HD frame within 1280x320 pixels, plus the balance of the frame (1280x400 pixels) allocated to display up to 4, full or half pixel resolution region of interest windows selected from anywhere within the 180° field of view at up to 15 frames/sec, and [2] a full pixel resolution 5120x1280 panoramic image at up to 1 frame/sec. Both the full 180° situational awareness view and the region of interest views shall be delivered simultaneously and be synchronized.
 - 8) The camera shall support flexible formatting of the HD video frame to include the following options: 180° situational awareness view only, 180° situational awareness view plus two regions of interest, 180° situational awareness view plus three regions of interest, and 180° situational awareness view plus four regions of interest.
 - 9) The camera shall be capable of displaying a rectangular overlay on the situational awareness view that indicates the position and size of a selected region of interest in the composite 720p video stream when selecting the window location .
 - 10) The camera shall be capable of allowing the user to quickly reposition the regions of interest in the composite video 720p frame.
 - 11) The camera shall have Auto Exposure with two exposure modes, Average mode and Independent mode. Average mode takes the exposure statistics for all of the image sensors and fixes the exposure for all of the camera modules based on the best average exposure. Independent mode allows each of the image sensors to set its own exposure based on its own exposure statistics.
 - 12) The camera shall feature Auto White Balance, which automatically sets the color channel gains, based on estimating the illuminant using AWB statistics for all of the image sensors.

- 13) The camera shall allow the white balance to be set manually by the user.
- 14) The camera shall allow the user to set the frame rate of the sensors from 1 fps to 15 fps.
- 15) The camera shall allow the user to set the image sharpening level with 4 levels of sharpening.
- 16) The camera shall allow the user to set the image contrast with 4 contrast curves.
- 17) The camera shall allow the user to adjust the exposure target to adjust the average image brightness.
- 18) The camera shall feature user-selectable 50/60 Hz flicker control.
- 19) The camera shall allow the user to adjust the geometrical alignment of the field of view to compensate for parallax in certain scenes.
- 20) The camera shall be capable of streaming video over a network.
- 21) The camera shall support TCP/IP, HTTP, SMTP, DHCP, RTP/RTSP, DNS, and BONJOUR network protocols.
- 22) The camera network interface shall be via an 8-pin RJ-45 connector. 10Base-T/100Base-TX Ethernet.
- 23) The camera shall be Power over Ethernet capable, compliant to the IEEE 802.3af standard.
- 24) The camera shall include an embedded web server, such that the standard web browsers Microsoft Internet Explorer 8 and higher, and Mozilla Firefox 3.6.1 or higher can be used to configure the camera and remotely view and record the D7-180 video streams. The supported operating systems shall be Windows 7, Windows Vista, and Windows XP.
- 25) The minimum system requirements to install and run the camera shall be:
 - a) Windows[®] XP (SP3 or higher), Windows Vista, Windows 7
 - b) 2.0 GHz CPU (Dual-core 1.8GHz or higher CPU recommended)
 - c) 2 GB RAM or higher
 - d) 200 MB hard drive space
 - e) Display adapter capable of 32 bit color depth or higher, 256 MB or higher video memory • Minimum display resolution 1280 x 1024
 - f) 10/100 Mb Ethernet adapter
 - g) 10/100 Router (Gigabit router recommended)*
 - h) PoE Switch*
 - i) Internet Explorer 8 or higher or Mozilla Firefox 3.6.1 or higher
 - j) *Optional depending on the deployed network topology
- 26) The camera shall have 2 user level settings. The Admin user level allows the user to configure and control the camera. The Viewer user level allows the user to view video streams.
- 27) The maximum frame rate capability of the camera over LAN shall be up to 15 frames per second at 1280x720 and 1 frame per second at 5120x1280 for H.264 compression. Both video streams shall be available simultaneously.
- 28) The camera shall have the capability to stream H.264 video in the following protocols: TCP/IP, HTTP, SMTP, DHCP, RTP/RTSP, FTP client, DNS, UPnP, and Bonjour.
- 29) The camera shall provide user authentication that allows a system administrator to prevent unauthorized access to the camera. Authentication shall consist of a challenge to provide the correct user name and password.
- 30) The camera shall have both FTP client and server capabilities.
- 31) The camera shall be capable of Date/Time superimposition on the video images. Additionally, a camera ID consisting of characters and numerals can

- be set by the user. Camera ID and Date/time shall be capable of being turned on or off independently.
- 32) The electronic shutter shall be able to record exposures in the range between 1/10,000 sec and 1/10 sec. The maximum sensor integration time is 1/15 sec.
 - 33) The camera shall be capable of being installed outdoors in temperatures as low as -40°F using an optional heater/blower kit available from the manufacturer.
- d. Camera Lens Specifications:
- 1) The camera shall be equipped with 5 fixed focus lenses with integrated IR cut filters.
 - 2) The focal length of each of the 5 lenses shall be 2.75mm. The total field of view coverage of the camera shall be 180° horizontal by 48° vertical.
 - 3) The camera shall have depth of field from 1 ft. to infinity.
- e. Video-Electrical Requirements:
- 1) The camera's input power shall accept a power voltage of DC 12V, and shall be Power over Ethernet (PoE) IEEE 802.3af standard compliant.
 - 2) The camera shall require a minimum scene illumination of 0.5 lux.
 - 3) The camera shall have streaming video output of two streams over Ethernet.
 - 4) The global auto white balance function shall work for illuminants in the range of 2000° K– 10000°K.
 - 5) The power consumption of the camera shall be 8 watts maximum.
 - 6) The camera shall be FCC Part 15, Class A, CE, CSA, and RoHS compliant.
 - 7) The camera shall have a two year warranty.
- f. Mechanical Requirements
- 1) The camera dimensions shall be approximately 3.28"W x 5.72"H x 2.49"D (83mm x 145mm x 63mm).
 - 2) The camera shall weigh approximately 11.6 oz (329 g).
 - 3) The camera body shall be constructed of impact resistant polycarbonate materials.
 - 4) The network interface shall be via RJ-45 located on the rear of the camera.
 - 5) The camera shall be capable of being mounted outdoors using an optional outdoor housing kit, DW02-100-010.
 - 6) The camera shall be capable of being flush-mounted to a wall or ceiling using an optional Flush mount kit DW01-100-003.
- g. Environmental Requirements
- 1) The operating temperature shall be within the range -40°F to 140°F (-40°C to 60°C). 2. The storage temperature shall be within the range -40°F to 185°F (-40°C to 85°C)
- h. Supplied Accessories
- 1) The camera kit shall include a 12v DC power supply.
 - 2) The camera kit shall include a surface mounting kit, and an angle mounting kit.

L. VIDEO MANAGEMENT SYSTEM DESCRIPTION

1. The Video Management System (VMS) software shall be used to view live and recorded video from IP devices connected to local and wide area networks. The VMS software shall have a client/server-based architecture that can be configured as a standalone VMS system with the client software running on the server hardware and/or the client running on any network-connected TCP/IP workstation. Multiple client workstations shall be capable of simultaneously viewing live and/or recorded video from one or more servers.

- Multiple servers shall also be able to simultaneously provide live and/or recorded video to one or more workstations.
2. The VMS shall not charge for the number of concurrent clients.
 3. The VMS system shall utilize manufacturer built servers, commercial-off-the-shelf (COTS) computer workstations, servers, networking devices and storage equipment.
 4. Recording of all video transmitted to the VMS shall be continuous, uninterrupted and unattended.
 5. The VMS system shall offer the capability of video motion detection recording, such that video is recorded when the NVRMS detects motion within a region of interest of the camera's view. Video prior to the detection of the motion shall also be stored with using the pre-recorded feature.
 6. The VMS system shall manage the video it has been configured to monitor. Loss of video signal shall be configured to annunciate on VMS client by an on screen visual indication alerting operators of video loss.
 7. The VMS software shall have an open architecture supporting IP cameras and encoders from multiple manufacturers providing best-of-breed solutions ranging from low-cost, entry-level features to high-resolution, megapixel features.
 8. The VMS client software shall be able to view live video and audio, recorded video and audio, and be able to configure the complete system all from a single application.
 9. The VMS shall continue to record video and audio at all times during the administration and configuration of any feature.
 10. The VMS client software shall have the same functionality when connected remotely as it does when it is run locally on the same computer as the server software.
 11. The VMS client software shall add and remove features based on the permissions of the user and the licensed functionality.
 12. The VMS client software shall operate on all of the following operating systems:
 - a. Microsoft Windows Server 2003/2008
 - b. Microsoft Windows XP (all versions)
 - c. Microsoft Windows Vista (all versions)
 - d. Microsoft Windows 7 (all versions)
 - e. Linux Ubuntu 8.04/10.04
 - f. Mac OSX (operating on Intel CPU)
 13. The VMS software shall allow the user to have any combination of VMS client applications running on any of the supported operating systems be able to connect to any of the VMS servers running on any of the supported operating systems. For example, a VMS client running on Microsoft Windows 7 shall be able to simultaneously connect to four (4) different VMS servers all running on different operating systems, such as Windows Server 2003, Windows XP, Vista, and Linux.
 14. The VMS software shall have the capability to run multiple client applications simultaneously on one workstation with multiple monitors. Up to 12 monitors shall be configured on a single workstation with one (1) client application running on each monitor. Because decompressing video is CPU-intensive, the PC workstation shall have multiple core processors, with a recommendation of one core for each VMS client application.
 15. The VMS shall also allow an authorized user to view video through a web client interface. The web client interface shall allow authorized users to view live video, view recorded video, control pan-tilt zoom (PTZ) cameras and activate triggers. The web client interface shall allow connections to multiple VMS servers simultaneously.
 16. The web client interface shall operate without requiring installation of any software.
 17. When using the web client interface, the VMS server shall transcode the video into a JPEG file of the size as the browser screen before sending it to the browser.

18. The web client interface shall support the following browsers:
 - a. Internet Explorer 6 and later
 - b. Firefox 2 and later
 - c. Opera 9 and later
 - d. Safari and later
 - e. Chrome
19. The web client interface shall also connect with non-JavaScript browsers and shall be compliant with HTML 4.0 (www.w3.org).
20. The VMS server software shall record and retrieve video, audio and alarm data and provide it to the VMS clients upon request.
21. The VMS software shall provide at no additional charge a purpose built mobile application capable of viewing multiple simultaneous live video streams and playing a recorded video stream. Application shall be provided for both iOS and Android operating systems (including Kindle Fire).
22. The VMS server software shall operate on any of the following operating systems:
 - a. Microsoft Windows Server 2003/2008
 - b. Microsoft Windows XP (all versions)
 - c. Microsoft Windows Vista (all versions)
 - d. Microsoft Windows 7 (all versions)
 - e. Linux Ubuntu 8.04/10.04 Debian Package
23. The VMS server shall not decode video for the purpose of motion detection.
24. The VMS server shall not decode video for the purpose of repacking it for transmission to clients.
25. The VMS server software shall record video based on metadata generated by an edge network device. The edge network devices shall generate the metadata and transmit it with the video stream to the VMS server software.
26. The VMS shall license the total number of cameras on the system. This license shall be based on the MAC address of a single network card that is present on the system. The VMS shall only require that this network card be enabled and does not require that data is actually sent through it.
27. The VMS shall not require the manufacturer to be contacted when a camera fails.
28. The VMS server software shall run as a service. The VMS shall not require any application to be running in order to operate.
29. The VMS shall allow the use of maps. The maps will be accessible to users with the appropriate permission levels and display video sources and their status.
30. The VMS allows soft triggers to be placed, viewed and triggered from a map.
31. The VMS software shall allow the use of a command line integration. The command line shall allow for the calling up the appropriate video when requested using command line functionality.
32. The VMS shall support the use of a panoramic lens on an analog or IP camera. The VMS client shall de-warp the image on both live and recorded video.

M. VIDEO MANAGEMENT SYSTEM SOFTWARE FEATURES

1. When in live display mode, the user shall be able to view live video, live audio, point of sale (POS) data, and alarm information.
2. The VMS shall be able to organize the camera video view panel in the following patterns:
 - a. 1-camera (full-screen) layout
 - b. 4-camera (2x2) layout
 - c. 8-camera (3 large views and 4 small views) layout
 - d. 10-camera (2 large views and 8 small views) layout
 - e. 13-camera (1 large view and 12 small views) layout

- f. 16-camera (4x4) layout
 - g. 8-camera (1 very large view and 7 small views) layout
 - h. 9-camera (3x3) layout
 - i. 6-camera (2x3) widescreen layout
 - j. 12-camera (4x3) widescreen layout
 - k. 20-camera (5x4) widescreen layout
 - l. 30-camera (6x5) widescreen layout
 - m. 48-camera (8x6) widescreen layout
3. The VMS shall provide an option to view 16:9 wide video display panels.
 4. The VMS shall allow the customization of the user interface to allow software triggers to be shown. This shall allow them to activate events through the push of a button, which could trigger recording, PTZ presets, output triggers or email.
 5. The VMS shall allow the user to pick their own icon and select the software triggers to display in the client. The VMS shall also display the status of any soft triggers on connected VMS servers.
 6. The VMS software shall allow control of PTZ cameras to authorized users and be used to maneuver a PTZ camera. When used on a non-PTZ camera, it shall allow you to digitally pan, tilt, and zoom on any video whether in live or recorded mode.
 7. The VMS shall allow following methods of controlling a PTZ camera to be available:
 8. PTZ graphics control windows
 9. Live graphic overlay PTZ control icons
 10. Keyboard control (up, down, left, right arrows; page up, page down for zoom)
 - a. PTZ presets
 - b. Digital PTZ
 - c. USB joystick to control PTZ cameras
 - d. Proportional PTZ control by clicking the mouse in the center and moving it
 11. The VMS software shall allow virtual matrix functionality by designating a cell to do so. This video cell shall automatically show video as it is triggered.
 12. The VMS software shall have a feature for viewing logical groups of cameras. This shall allow efficient viewing of cameras in a logical order.
 13. The VMS software shall have a feature to organize your cameras into preset views. Views are preconfigured arrangements of the video panels so that they may be easily recalled later. A view can save the location of the video streams, audio streams, POS data, maps and event views. These views shall be accessible in both live and recorded video modes.
 14. The VMS software shall have the capability to automatically cycle through two or more saved views to create a video tour. The VMS shall allow the configuration of the dwell time and the different views it shall use.
 15. The VMS client software shall be used to search for and play back recorded video, audio, and events from VMS servers.
 16. The VMS software shall have the capability to search for and play back video from multiple cameras simultaneously. All recorded video shall be played back and displayed in a synchronized multi-camera layout.
 17. The VMS software shall support searching through recorded video based on time, date, video source, image region and have the results displayed as both a clickable timeline and a series of thumbnail images.
 18. The VMS software shall allow search and play back of audio in synchronization with video.
 19. The VMS software shall allow you to search on a specific area of recorded video and only display the frames where motion happened in that area.

20. The VMS software shall have the capability to export video, maps, POS data and audio files.
21. The VMS software shall provide the option of exporting the file in the following formats:
 - a. Standalone Exe (*.exe) – includes an executable player with the video and audio data
 - b. AVI File (*.avi) – a multimedia container format
 - c. PS File (*.ps) – a format for multiplexing video and audio
 - d. QuickTime File (*.mov) – native for Macintosh computers
22. The VMS standalone player shall package all of the exported video into a single executable. The VMS standalone player shall be able to authenticate that the video has not been tampered with using a keyed Hash Message Authentication Code (HMAC).
23. The VMS client software shall be able to connect to multiple systems simultaneously. Each of the systems could have individual permissions, thereby limiting the client's configuration or viewing abilities for that system, but not affecting the abilities on the other systems.
24. The VMS system shall be able display system information about users that are currently logged into the system, plug-in file version information number and status, and a system log that contains a detailed history of the process that occur on the system.
25. The VMS system shall have the ability to record an audit trail of when users log in that shows what changes they have made, what video they have viewed and what they have exported.
26. The VMS system shall allow the configuration of the video devices to be performed in the client, and pushed out to the devices. The configuration itself is stored both on the camera and on the VMS.
27. The VMS shall allow monitoring of the inputs on both network devices and on manufacturer provided hardware. The VMS shall also allow triggering of outputs on the network devices and manufacturer provided hardware.
28. The VMS shall allow for the configuration of what drives to use for recording video. Those drives may be local drives, direct attached storage drives or iSCSI drives.
29. The VMS shall allow for the configuration of rules of how to record the video. These rules shall allow you to set a maximum number of days or minimum number of days on a per video stream basis.
30. The VMS shall not require a database when recording video.
31. The VMS shall use the operating systems native file system for recording the video. For example, if there was video that
32. was recording on March 1, 2012 from 10:00 AM to 10:35 AM. Files for that day would be in the data drive, in the path 2012 for year, subfolder 03 for the month, with a sub folder 1st for the day, and then the 10 sub-folder for the hour. So when the client sends a request to search for video, the VMS shall look in the D:\2012\03\01\10 directory. Each video stream shall be kept in 5 minute increments in a paired video and index file. The video file shall contain the data of the video, audio, and include meta data. The index file shall contain the index of the metadata from the network device. So when the VMS searches for the video, it shall gather up the information in the index files and display those results. When the client then requests to display the video, the VMS will then transmit the video file data from the server to the client.
33. The VMS shall have the ability to receive ASCII data through the COM port on the server, or over the network.

34. The VMS shall have the ability to look for keywords in the ASCII data and use these to execute various events such as PTZ presets, recording video, recording audio and sending emails notifications.
35. The VMS software shall be able to send a predefined email based on an event trigger. The VMS software shall also support SSL and TLS connections for transmissions of the mail.
36. The VMS software shall have a feature to export a video segment from specific cameras or audio inputs to a CD or DVD upon an input trigger or other event being activated.
37. The VMS software shall be used to connect different types of events, such as input triggers, to a desired action such as recording video or triggering an alarm. The VMS software shall recognize the following event types:
 - a. Video Motion
 - b. Video Loss
 - c. Input Trigger
 - d. POS Port
 - e. POS Profile
 - f. Health
 - g. IP Camera Connection
 - h. Software Trigger
 - i. Analytics
38. The VMS software shall be able to execute the following action types:
 - a. Record Video
 - b. Output Trigger
 - c. Output Video
 - d. Send an email
 - e. Burn a CD/DVD
 - f. Call a PTZ Preset
39. The VMS software shall have the ability to configure each video inputs recording time on an hourly basis. This shall allow the user to schedule when to record on motion, when to record on event and when to not record.
40. The VMS shall use a combination of user name and password to authenticate the user's permission level.
41. The VMS shall allow granularity of permissions by creating custom user groups. The members of these custom user groups shall all have the same permissions.
42. The VMS client shall be able to use Open GL and Direct 3D to decompress and render video.
43. The VMS shall allow the user to perform a visual thumbnail search. The user can select one camera to see one image per set time period. The user shall be able to play video from that image or and zoom in to a time range.
44. The VMS client can be configured to automatically switch views on any trigger within the event monitoring function.
45. The VMS software shall allow the user to input time-based triggers through event monitoring, including the time of day and day of week.

N. SERVER NETWORK VIDEO RECORDER HARDWARE FEATURES

1. The server hardware shall run on the Windows 7 Pro or Server 2008 operating system. Windows shall boot and run on a 128 GB solid-state drive (SSD) to ensure high performance and reliability.
2. The server shall be capable of simultaneously recording, displaying and playing back digitized video from IP cameras and analog cameras through the use of a video encoder.

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- IP Server models shall be capable of being licensed to add IP cameras in increments from one (1) to 64 camera licenses.
3. The server shall support recording resolutions from CIF to 20 megapixel (camera dependent) and shall be user selectable. MJPEG, MPEG-4 and H.264 video compression format shall be user selectable depending on the IP camera configured to the IP Server. Video recording shall be available at up to 30 images per second per input channel depending on IP camera type selected.
 4. Each server shall have serial port capabilities to communicate with serial devices such as point of sale (POS) terminals and automated teller machines (ATM). Once the serial device is connected to the serial port with a cable the serial port shall be configured. Transaction data shall be received from each serial device into a text database and associated with recorded video. User shall be able to search transaction data to locate the associated video.
 5. Each server shall have a serial port capable of communicating with pan-tilt-zoom (PTZ) cameras.
 6. Each server shall have two Gbit 1000Base T RJ-45 Ethernet connections for networking to Remote PC clients. Multiple servers shall be accessible by multiple clients located anywhere on the network. Each server shall record video, audio, and text while displaying live video or playback video. In the event that there is no client actively attached to the server, the server shall continue to record video and audio, monitor events and all other server functions.
 7. Recorded video shall be triggered by the motion detection sensor of the IP camera, an external input device, or in continuous record mode.
 8. Each server shall have the capability of automatically exporting a predetermined time frame of video to the internal DVD/CD device upon an external trigger input connected to the server. Such input shall export to the DVD/CD device a user defined amount of video and video camera source both pre and post event schedulable to the maximum capacity of the DVD/CD media selected.
 9. Each server shall have the ability to link specific events in an “if-then” scenario. Linked events types shall include video motion, video loss, input trigger, POS port, POS profile and temperature. Sources of these events shall be any camera connected to the specific server. Action from these events shall include record video, record audio, enable output trigger, output video, notify (send e-mail), and output video to DVD.
 10. The server hardware shall have an internal DVD/CD device that will allow the server to export video clips to the device in Standalone.Exe (*.exe), AVI files (*.avi) and PS files (*.ps) formats.
 11. K. A RAID-5 option shall be available consisting of a 4U chassis and eight hot swappable hard drives. The RAID-5 option shall be internal to the server and shall provide notification of a drive failure to the administrator.

O. SEVER SPECIFICATIONS

1. 2U Rackmount IP Server
2. All 2U Rackmount Servers shall have the following specifications:
 - a. Dimensions (L x W x H): (21.25” x 16.75” x 3.5”) (54.7 x 42.6 x 8.9 cm)
 - b. Weight: 27 – 31 lbs. (12.3 – 14.1 kg)
 - c. Input Voltage: 120/240 VAC auto-sensing
 - d. Power Consumption: <250 watts (150 watts typical)
 - e. Video Standard: NTSC (30ips) or PAL (25ips)
 - f. Recording Resolution: CIF to 20 megapixel (camera dependent)
 - g. Compression: MJPEG, MPEG-4 or H.264 by camera or encoder
 - h. Alarm Inputs: 0

- i. Alarm Outputs: 0
 - j. Serial Connections: RS-232
 - k. NIC: 2 Gbit 1000Base T RJ-45 (standard), 4 (optional)
 - l. USB 2.0 Ports: 8 (8 x USB 2.0)
 - m. Audio Inputs:0
 - n. Audio Outputs: 1
 - o. Hard Drive Storage: Enterprise Class
 - p. VGA Output: 1 DVI-A + 1 DVI-D + 1 Display Port
 - q. maximum 2 simultaneous monitors
 - r. Keyboard & Mouse: Included
 - s. DVD/CD RW: Included, front panel access
 - t. Operating System: Windows 7 Pro 64 Bit or Server 2008 on 128 GB SSD Partition
 - u. Operating Temperature: 40° – 95°F (4.5° – 35°C)
 - v. Relative Humidity: 5 – 95% RH (non-condensing)
 - 3. In addition the 2 RU Rackmount server will have 8 Hot Swappable 3.5” Removable Hard drive bays, SSD OS drive. server class motherboard, Intel 3.2 Ghz Xenon processor.
 - 4. SERVER CERTIFICATIONS
 - a. CE and FCC, Class A and B (all models) and UL Listed (except the Desktop Server)
 - 5. SERVER WARRANTY
 - a. 3-year warranty on parts and labor and a 3-year Software Subscription Agreement (SSA)
- P. 2.07 VIDEO MANAGEMENT SYSTEM HARDWARE
- 1. Minimum Server Requirements
 - a. The VMS server software shall operate on the following minimum requirements:
 - b. Processor: Intel® Xenon Processor 3.2 GHz or greater
 - c. Graphics: 1280x1024x32 bits
 - d. RAM: 4 GB
 - e. NIC: 1x100 Mbps (minimum), 1 Gbps (preferred)
 - f. Disk Drive:
 - g. JBOD, Minimum sustained non-sequential write capacity 15 Mpbs,
 - h. Digital Enterprise Class drive (RE4 or better), or
 - i. Seagate Barracuda ES.2 drives or better
 - j. Operating Systems:
 - 1) Microsoft® Windows 2003 Server (all versions)
 - 2) Microsoft® Windows 7 Pro 64 bit
 - 3) Linux Ubuntu 8.04 or higher
 - 2. Minimum Client Requirements
 - a. Processor: Intel® Atom D525 1.8 GHz or greater
 - b. Graphics: 1280x1024x32 bits
 - c. RAM: 1 GB
 - d. NIC: 10/100/1000 baseT Ethernet
 - e. Disk Drive: Western Digital Enterprise Class drive (RE4 or better), or
 - f. Seagate Barracuda ES.2 Drives or betted
 - g. Operating Systems:
 - 1) Microsoft® Windows XP (all versions) or higher
 - 2) Linux Ubuntu 8.04 or higher
 - 3) Mac OSX 10.4 or higher
 - 3. Recommended Server Requirements

- a. Processor: Intel® Core i7-2600 Processor, 3.4 GHz or Xeon E3-1220
- b. Graphics: 1280x1024
- c. RAM: 4 GB
- d. NIC: 2x1Gbps (minimum), 4x 1 Gbps (preferred)
- e. Disk Drive: RAID-5 (minimum), RAID-6 (preferred), minimum sustained non-sequential write capacity 70 MBps
- f. Operating Systems:
 - 1) Microsoft® Windows XP (all versions)
 - 2) Microsoft® Windows Vista (all versions)
 - 3) Microsoft® Windows 2008 Server (all versions)
 - 4) Microsoft® Windows 7 Pro (all versions)
 - 5) Linux Ubuntu 10.04 LTS
- g. Recommended Client Requirements (Single Monitor)
 - 1) Processor: Intel® Core i3 2100 Processor, 3.1 GHz or greater
 - 2) Graphics: 1280x1024x32 bits
 - 3) RAM: 2 GB
 - 4) NIC: 10/100/1000 baseT Ethernet
 - 5) Disk Drive: Western Digital Enterprise Class drive (RE4 or better), or Seagate Barracuda ES.2 Drives or better
 - 6) Video: 64 MB video card (Direct3D / OpenGL compatible)
 - 7) Operating Systems:
 - a) Microsoft® Windows 7 (all versions) or higher
 - b) Linux Ubuntu 8.04 or higher
 - c) Mac OSX 10.4 or higher
- h. Recommended Client Requirements (Multi-Monitor)
 - 1) Processor: Intel® Core i7 or greater
 - 2) Graphics: Multi-output display adapter
 - 3) RAM: 4 GB
 - 4) NIC: 10/100/1000 baseT Ethernet
 - 5) Disk Drive: Western Digital Enterprise Class drive (RE4 or better), or Seagate Barracuda ES.2 Drives or better
 - 6) Video Card: 512 MB video card (Direct3D / OpenGL compatible)
 - 7) Operating Systems:
 - a) Microsoft® Windows XP (all versions)
 - b) Microsoft® Windows Vista (all versions)
 - c) Microsoft® Windows 2003 Server (all versions)
 - d) Microsoft® Windows 7 (all versions) or higher
 - e) Linux Ubuntu 10.04
 - f) Mac OSX 10.6

2.2 LCD 42 INCH SPOT MONITOR

- A. The **SONY 42 Inch #FWD-S42H1**, LCD monitor has been selected for this project.
- B. Basis-of-Design Product: **Subject to compliance with the indicated monitor requirements**, the following manufacturers are approved alternates:
 - 1. PANASONIC #PLCD42HD, Corporation of North America; Panasonic Security Systems
 - 2. Tote Vision, Seattle Washington – USA

2.3 MONITOR MOUNTING DEVICES

- A. **PEERLESS** mounting devices are required to mount the spot monitor to the ceiling.
- B. Approved alternate is Chief.
- C. It is the responsibility of the installer to verify the mounting devices required to ensure proper installation of the monitor is attained.
- D. Suggested mounting devices are shown within PART 4, PARTS LIST

2.4 VGA & AUDIO DEVICES TO SPOT MONITOR

- A. Audiovisual products have been specified to send video to the spot monitor from a remote location as shown on the IT drawings.
- B. The manufacturer for these products shall be **EXTRON** Electronics, www.extron.com
- C. Products are specified within the IT drawings and within PART 4, PARTS LIST.
- D. All cabling and connectors required for a fully connected and functional system are to be included with this portion of work.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway and mounting surfaces intended for the cameras. Check structure and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras level and plumb.
- B. Install cameras with 84-inch minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- D. Install power supplies and other auxiliary components within the Telecommunication Room unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected,

inconspicuous positions.

- F. Identify system components, wiring, cabling, and terminals according to industry standards.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: the contractor shall engage a qualified testing agency to perform tests and inspections with the Owner and/or technology consultant.
- 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. 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 "Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. 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.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. 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 fourteen (14) days. Provide a minimum of ten (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.
- E. Video surveillance system will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to this Project location 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.

3.5 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens before installation and prior to final acceptance.
- C. Remove rubbish and debris: Installation contractor is not allowed you use the onsite dumpster and is responsible to discard their own debris off site.

3.6 SERVICE LEVEL AGREEMENTS (SLA'S)

- A. The bidding contractor shall include pricing for a three (3) year SLA as part of the base bid and shall include the following procedures:
 - 1. Windows upgrades/patches shall be installed and updated 2X per year to the Video management Server and Network Storage Devices and the Paxton devices.
 - 2. Firmware updates shall be performed 2X per year to all of the cameras.
 - 3. Physical Maintenance shall be performed 2X per year on all of the cameras within this specification and shall minimally include:
 - a. Correct lens adjustments
 - b. Verify heating elements
 - c. Lens and enclosure cleaning
 - d. Secure screws

3.7 DEMONSTRATION – TRAINING

- A. Bidding contractor shall engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain video-surveillance system.

- B. The vendor shall provide various levels of training including advanced training (i.e., “Gold” level).
- C. Twenty-four (24) hours of training shall be included as part of this specification. These training hours shall be partitioned as the Owner mandates and as required.

END OF SECTION 282300

SECTION 283111 - 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.
- B. The Contractor, Subcontractors, and /or suppliers providing goods and services referenced in or related to this section will be required to support the Commissioning effort in accordance with the requirements identified in Section 019103 "Building Commissioning Requirements".

1.2 SUMMARY

A. Section Includes:

- 1. Fire-alarm control unit.
- 2. Manual fire-alarm boxes.
- 3. System smoke detectors.
- 4. Heat detectors.
- 5. Carbon monoxide detectors.
- 6. Notification appliances.
- 7. Firefighters' two-way telephone communication service (Area of Refuge).
- 8. Magnetic door holders.
- 9. Remote annunciator.
- 10. Addressable interface device.
- 11. Digital alarm communicator transmitter.
- 12. Radio alarm transmitter.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

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.

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 Engineer.
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 and/or Level IV 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.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
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.

D. Delegated-Design Submittal: For smoke and heat detectors 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. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. 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.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems and components to include in operation and maintenance manuals. In addition to items specified in Section 017823 "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.

I. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. 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.
- 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. NFPA Certification: Obtain certification according to NFPA 72

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 Architect no fewer than two (2) days in advance of proposed interruption of fire-alarm service.
 - 2. Do not proceed with interruption of fire-alarm service without Architect written permission.

1.9 SEQUENCING AND SCHEDULING

- A. The system alarm operation subsequent to the alarm activation of any manual pull station, sprinkler flow switch, hood suppression system or automatic detection device is to be in accordance with section 2.2 of this specification.
- B. Alarm Verification:
 - 1. The activation of any system smoke detector shall initiate an Alarm Verification operation whereby the panel will reset the activated detector and wait for a second alarm activation.
 - 2. If, within one (1) minute after resetting, a second alarm is reported from the same or any other smoke detector, the system shall process the alarm as described previously.
 - 3. If no second alarm occurs within one (1) minute the system shall resume normal operation.
 - 4. The Alarm Verification is to operate only on smoke detector alarms. Other activated initiating devices shall be processed immediately.
 - 5. The alarm verification operation is to be selectable by addressable device.
 - 6. The control Unit shall have the capability to display the number of times (tally) a device has gone into a verification mode. Should this smoke verification tally reach a pre-programmed number, a trouble condition shall occur.
- C. Supervisory Service:
 - 1. The control panel shall have a dedicated supervisory service condition and a dedicated supervisory service acknowledge switch.
 - 2. Activating the Supervisory Service Acknowledge Switch will silence the supervisory audible signal while maintaining the Supervisory Service listing on indicating the tamper contact is still in the off-normal state.
 - 3. Restoring the valve to the normal position shall cause the Supervisory Service indication to reset thus indicating restoration to normal position.
 - 4. Restoring the valve to the normal position shall cause the supervisory service audible signal to pulse thus indicating restoration to normal position.
 - 5. Activating the Supervisory Service Acknowledge Switch will silence the audible signal and restore the system to normal.

- D. A manual evacuation switch shall be provided to operate system alarm indicating appliances. Other control circuits shall not be activated. However, an actual alarm shall be processed as described previously.
- E. Activation of an auxiliary bypass switch shall override the automatic functions either selectively or throughout the system.
- F. Alarm and trouble conditions shall be immediately displayed on the control panel front.

1.10 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two (2) 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 thirty (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 Strobe Units: Quantity equal to ten percent (10%) of amount installed, but no fewer than one (1) unit.
 - 2. Smoke Detectors and Heat Detectors: Quantity equal to ten percent (10%) of amount of each type installed, but no fewer than one (1) unit of each type.
 - 3. Detector Bases: Quantity equal to two percent (2%) of amount of each type installed, but no fewer than one (1) unit of each type.
 - 4. Keys and Tools: One (1) extra set for access to locked and tamper-proofed components.
 - 5. Audible and Visual Notification Appliances: One (1) of each type installed.
 - 6. Fuses: Two (2) of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:
 - 1. Gamewell
 - 2. Notifier
 - 3. Siemens Building Technologies, Inc.; Fire Safety Division

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one (1) or more of the following devices and systems:
1. Manual stations.
 2. Heat detectors.
 3. Smoke detectors.
 4. Duct smoke detectors.
 5. Verified automatic alarm operation of smoke detectors.
 6. Automatic sprinkler system water flow and pressure.
 7. Heat detectors in elevator shaft and pit.
 8. Fire-extinguishing system operation (Kitchen Hood).
- B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm visual notification appliances until extinguished by the Alarm Reset Switch.
 2. Identify alarm at fire-alarm control unit and remote annunciators.
 3. Transmit an alarm signal to the remote alarm receiving station.
 4. Release fire and smoke doors held open by magnetic door holders.
 5. Activate voice/alarm communication system until silenced by the alarm silence switch or individual circuit switch at the control panel.
 6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 8. Recall elevators to primary or alternate recall floors.
 9. Activate emergency shutoffs for gas and fuel supplies.
 10. Record events in the system memory.
- C. Supervisory signal initiation shall be by one (1) 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.
 4. Generator general alarm switch.
 5. Carbon monoxide detector.
- D. System trouble signal initiation shall be by one (1) or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of primary power at fire-alarm control unit.
 4. Ground or a single break in fire-alarm control unit internal circuits.
 5. Abnormal ac voltage at fire-alarm control unit.
 6. Break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at fire-alarm control unit or annunciator.
 9. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
- E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators.

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) line(s) 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 B.
 - a. Initiating Device Circuits: Style B.
 - b. Notification Appliance Circuits: Style Y.
 - c. Signaling Line Circuits: Style 3.
 - d. Install no more than fifty (50) addressable devices on each signaling line circuit.
2. Serial Interfaces: Two (2) RS-232 ports for printers.

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. Sound general alarm if the alarm is verified.
 4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- E. Notification Appliance Circuit: Operation shall sound with an initial alert tone, followed by a pre-recorded emergency voice message of approximately fifteen (15) seconds, followed by a repeating alarm “whoop” tone.
- 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 hoistway.
 2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
 3. Heat detectors in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
- 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. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals and 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 eighty percent (80%) of the power-supply module rating.
- K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Vented, wet-cell pocket, plate nickel cadmium.
 2. System shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of sixty (60) hours with five (5) minutes of alarm operation at the end of this period.

- L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 - 2. Station Reset: Key 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.

2.5 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Detectors shall be two-wire type.
 - 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
 - 7. 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 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.
 - 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.).

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
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.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
7. Remote Test Switch: With keyed switch and LED indicator.

2.6 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 or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 CARBON MONOXIDE DETECTORS

- A. General Requirements for System-type Carbon Monoxide Detectors:
1. Comply with UL 2075 and UL 2034; operating at 24-V dc, nominal.
 2. Electrochemical sensing technology.
 3. Detectors shall be two-wire type.
 4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
- B. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

2.8 NOTIFICATION APPLIANCES

- 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 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 high letters on the lens.
1. Rated Light Output: 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.

D. Voice/Tone Notification Appliances (Speakers):

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Low-Range Units: Rated 1 to 2 W.
4. Mounting: Flush.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.9 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION (AREA OF REFUGE)

- A. System shall be hands free and shall comply with the Americans with Disabilities Act providing two-way voice communications.
- B. Units shall have dual audio and visual alarms.
- C. System shall provide supervision of area stations and wiring.
- D. System shall be furnished complete with all relay cards, amplifiers, etc as required for operation. System shall also be furnished with battery backup or shall be tied to fire alarm system for battery backup. Adjust fire alarm battery capacity accordingly. Equipment enclosures shall be surface mount type.
- E. Furnish specified Cornell system or equal by Housing Devices, Inc. Master unit shall have spare capacity as indicated on Drawings.

2.10 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate. Projection of holder and armature must be coordinated with other hardware and wall conditions to ensure that door sits parallel to wall when fully open. Where magnetic holders are used on fire-rated doors, they must be wired into the fire control panel for fail-safe operation.
 1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 3. Rating: 120-V ac; or 24-V ac or dc.
- B. Material and Finish: Match door hardware.
- C. Acceptable Manufacturers and/or Products: LCN, Rixson, Sargent.

2.11 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.

2.12 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, to circuit-breaker shunt trip for power shutdown and other functions as required.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two (2) telephone lines 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 one (1) of the lines is interrupted for longer than forty-five (45) seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address 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. Control panel and NAC panel shall receive 120 VAC power via a dedicated branch circuit protected in accordance with the National Electric Code.
 - 1. The system shall support one hundred percent (100%) of notification and initiating devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.

2. System shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of sixty (60) hours with five (5) minutes of alarm operation at the end of this period. Any system cabinets furnished with independent power supplies and/or batteries shall also meet these requirements.
3. System shall automatically transfer to standby batteries upon power failure. All battery charging and recharging operations shall be automatic.
4. All circuits requiring system operating power shall be 24 VDC and shall be individually fused or equivalently protected at the control unit.
5. The incoming power to the system shall be supervised so that any power failure must be audibly and visibly indicated at the control unit and the annunciator. A green "power on" LED shall be displayed continuously while incoming power is present.
6. If a "LOW BATTERY" condition is left unattended a second stage "DEPLETED BATTERY" trouble condition shall be audibly and visibly reported at the control unit indicating the batteries are below the listed system operating voltage.
7. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visibly indicated at the control unit and the annunciator.

- F. Self-Test: Conducted automatically every twenty-four (24) hours with report transmitted to central station.

2.14 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 COMMISSIONING OF SYSTEMS AND EQUIPMENT

- A. Engage a factory-authorized service representative or technician who is familiar with this project to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Equipment Mounting: Install fire-alarm control unit on wall with tops of cabinets not more than 72 inches above the finished floor.
- C. Smoke- or Heat-Detector Spacing:
1. Smooth ceiling spacing shall not exceed 30 feet.
 2. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.

3. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
 4. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.
- D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
 - E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
 - F. 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.
 - G. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
 - H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.
 - I. Device Location-Indicating Lights: Locate in public space near the device they monitor.
 - J. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.3 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 1. Smoke dampers in air ducts of designated air-conditioning duct systems.
 2. Alarm-initiating connection to elevator recall system and components.
 3. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 4. Supervisory connections at valve supervisory switches.
 5. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
 6. Supervisory connections at elevator shunt trip breaker.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

- B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 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.

3.6 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- 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. 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 "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 carbon monoxide detectors in accordance with NFPA 720.
 - 4. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 5. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 6. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 7. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

- G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- H. Annual Test and Inspection: One (1) 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.

3.7 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 283111

SECTION 31 1100 - CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes
 - 1. Cutting of trees and other vegetation
 - 2. Removal of roots and related growth.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.
- C. Contractor is responsible for all health and safety.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- C. Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction

1.3 DEFINITIONS

- A. Clearing: Clearing shall consist in the felling, cutting up, and satisfactory disposal of trees and other vegetation designated for removal in accordance with these specifications.
- B. Drainage Course: Layer supporting basement grade used to minimize capillary flow of pore water.
- C. Grubbing: Grubbing shall consist of the removal of roots 1 ½ inch and larger, organic matter and debris, and stumps having a diameter of three inches or larger, to a depth of at least 18 inches below the surface and or subgrade; whichever is lower, and the disposal thereof.

1.4 SAFETY REQUIREMENTS

- A. Contractor shall conduct all clearing and grubbing activities in conformance with applicable regulations, including those relating to barriers, warning signs, excavation safety, sheeting, shoring, and stabilization.
- B. Contractor shall provide and maintain barricades, warning signs, signs, lights, etc., required for the protection of personnel, materials and property. Temporary barricades, etc. shall conform all applicable codes and regulations, and shall be lighted at night with lanterns,

flares and reflectorized paint as required for safety. Adapt barricades, signs, lights, etc. to evolving site conditions throughout the progress of the work.

- C. Provide other safety devices as required, including adaptation of such safety devices to changing site conditions, to prevent unauthorized entry to construction areas. Provide warning signs and other temporary construction safety devices necessary for proper completion of the work in compliance with applicable safety regulations.

1.5 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained, experienced, and as required licensed, in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 PREPARATION

- A. Secure the work area and take precautions for preventing injuries to persons or damage to property in or about the work. Protect structures, utilities, sidewalks, pavements and other facilities or sensitive areas from damage by clearing and grubbing operations.
- B. Establish all required erosion and sedimentation controls prior to initiating work.

3.2 CLEARING AND GRUBBING

- A. Clear, grub, remove, and dispose of all vegetation and debris within the limits of construction, as designated on the plans or as required by Engineer. Contractor shall remove only those trees and shrubs absolutely necessary to allow for the construction. The work shall also include the preservation and protection of all vegetation designated to remain.
- B. A preconstruction meeting shall be held with Engineer, Owner, local authorities, property owner(s) and other appropriate personnel, if required, prior to any clearing.
- C. The area within the limits of construction or as designated shall be cleared and grubbed of all trees, stumps, roots, brush, undergrowth, hedges, heavy growth of grasses or weeds, debris and rubbish of any nature which, in the opinion of Engineer, is unsuitable for foundation material. Nonperishable items that will be a minimum of five (5) feet below the finish elevation of the earthwork or slope of the embankment may be left in place.
- D. Contractor shall provide barricades, fences, coverings, or other types of protection necessary to prevent damage to existing improvements, not indicated to be removed, and improvements on adjoining property. All improvements damaged by this work shall be restored to their original condition or to a condition acceptable to the owner or other parties or authorities having jurisdiction.
- E. Protection of Trees and Vegetation: Contractor shall protect existing trees and other vegetation indicated on the Drawings to remain in place against cutting, breaking, or skinning of roots, skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular

traffic, or parking of vehicles within drip line. Provide temporary fences or barricades as required to protect trees and vegetation to be left standing at no additional cost.

- F. Trees and shrubs that are to remain within the construction limits will be indicated on the Drawings or conspicuously marked on the Project Site. Unless otherwise noted, trees within the construction limits shall become the property of the Contractor and shall be removed from the site.
- G. Carefully and cleanly cut roots and branches of trees indicated to remain where the roots and branches obstruct construction of utilities or other subsurface improvements. Contractor shall provide protection for roots and branches over 1 ½ inches diameter that are cut during construction operations. Temporarily cover all exposed roots with wet burlap to prevent roots from drying out. Provide earth cover as soon as possible.
- H. Damaged trees and vegetation designated to remain shall be repaired or replaced at Contractor's expense in a manner acceptable to Engineer if they are damaged by construction operations. Repair tree damage as directed by a qualified tree surgeon.
- I. Trees and vegetation designated to remain shall be repaired or replaced at Contractor's expense in a manner acceptable to Engineer if they are damaged by construction operations. Repair tree damage as directed by a qualified arborist.
- J. All brush, tree tops, stumps, and debris shall be hauled away and disposed of in accordance with all applicable laws and regulations. Contractor shall clean up debris resulting from clearing operations continuously with the progress of the work and remove promptly all salvageable material that becomes his property and is not to be reused in construction. Sale of material on the site is prohibited. Debris from the site shall be removed in such a manner as to prevent spillage. Keep pavement and area adjacent to site clean and free from mud, dirt, dust, and debris at all times.
- K. The method of stripping, clearing and grubbing the site shall be at the discretion of the Contractor. However, all stumps, roots and other debris protruding through the ground surface or in excavated areas shall be completely removed to a minimum depth of 18 inches below surface and/or subgrade whichever is lower and disposed of off the site by the Contractor, at his expense.
- L. Marginal Areas: In marginal areas, with Engineer's permission, remove trees where the following conditions exist.
 - 1. Root Cutting: When clearing up to the "clearing limits," the Contractor shall also remove any tree which is deemed marginal such that when the roots are cut and the tree could be rendered unstable by the affects of high winds and in danger of toppling into either the right-of-way or onto private property.
 - 2. Slender Bending Trees: Where young, tall, thin trees are left unsupported by the clearing operation, and are likely to bend over into the right-of-way, Contractor, during the clearing operation, shall selectively remove those trees which are located outside and adjacent to the clearing limits and any right-of-way or easement as well. During the course of construction and during the one-year warranty period, the Contractor shall remove such young trees that overhang into the right-of-way or cleared area.

- M. Stripping of Topsoil: Remove the existing topsoil to a depth of 6 inches or to the depth encountered from all areas in which excavation will occur. The topsoil shall be stored in stockpiles, separate from the excavated material, if the topsoil is to be respread. Otherwise material shall be disposed of off-site at Contractor's expense.

3.3 DISPOSAL

- A. Contactor shall consolidate and clean-up debris resulting from clearing and grubbing operations continuously with the progress of the work.
- B. All brush, treetops, stumps, and debris resulting from clearing and grubbing operations shall be hauled away and disposed of in accordance with all applicable laws and regulations. Any materials salvaged by Contractor from clearing and grubbing operations shall be promptly removed from the Project Site.
- C. Contractor will be responsible for obtaining all applicable permits and paying all fees for the disposal of excess material.
- D. Sale of material on the Project Site is prohibited.
- E. Burning of material is prohibited.

END OF SECTION

SECTION 312113 – RADON MITIGATION

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 systems for the following:
 - 1. Radon system
 - 2. Sub-slab ventilation system
- B. Related Sections include the following:
 - 1. Section 310220 “Building Earthwork” for soil materials, filter fabrics, and vapor retarders.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. HDPE: High-density polyethylene plastic.
- C. PE: Polyethylene plastic.
- D. PP: Polypropylene plastic.
- E. PS: Polystyrene plastic.
- F. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Perforated-wall pipe and fittings.
 - 2. Solid-wall pipe and fittings.
 - 3. Vapor barriers.
 - 4. Filter fabric
- B. Approval of waterproofing manufacturer's service agent for use of drainage panels against and for waterproofing membrane protection.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

- A. Refer to the "Piping Applications" Article in Part 3 for applications of pipe, tube, fitting and joining materials.

2.3 PIPES AND FITTINGS

- A. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.
 - 1. Gaskets: ASTM C 443 (ASTM C 443M), rubber.
- B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste and vent patterns.

2.4 SPECIAL PIPE COUPLINGS

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.
 - 1. Sleeve Materials:
 - a. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 2. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant metal tension band and tightening mechanism on each end.
 - 3. Shielded Flexible 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.

2.5 SOIL MATERIALS

- A. Backfill, drainage course, impervious fill and satisfactory soil materials are specified in Section 310220 "Building Earthwork".

2.6 FILTER FABRIC AND VAPOR RETARDER

- A. Filter fabrics and vapor retarders are specified in Section 310220 "Building Earthwork".

2.7 RADON EXHAUST FAN – NOT PART OF SCOPE-FOR INFORMATION ONLY

- A. Description: In-line type, mounted in radon stack on roof.

1. Ratings: 510 CFM at 0 inch external static pressure.
2. Provide Fernco transition fitting secured with stainless steel bands to fan's 8 inch inlet from 6 inch Radon vent piping.
3. Operation: Fan shall run continuously, through local disconnect switch.
4. Electrical Requirements: 115 volts; 1 phase; Coordinate power wiring and local disconnect switch provision by the Electrical Contractor.
5. Basis of Design: Radonaway **Model RP-380**

2.8 RADON SYSTEM PRESSURE MONITOR

- A. Description: Pressure switch/alarm, with warning signal relay, mounted in each main radon exhaust riser to roof. Provide fire-rated access door to service pressure switch/alarm device, if device is located in chase or inaccessible ceiling.
1. Operation: Pressure switch/alarm shall activate at 0.25 inch w.c.
 2. Alarm Requirements: Coordinate wiring of alarm into the Building Management System. Refer to Section 230900 "Instrumentation and Control for HVAC".
 3. Basis of Design: Radonaway **Checkpoint IIa**

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where radon and sub-slab ventilation systems are to be installed.
- B. Coordinate installations of this Section with all other trades, particularly structural and concrete work.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Excavating, trenching and backfilling are specified in Section 310220 "Building Earthwork".

3.3 PIPING APPLICATIONS

- A. Under-slab Radon and Sub-slab Ventilation Piping (within the radon suction pit):
1. Pipe in subparagraph (2) below is available in NPS 4 (DN 100) only.
 2. Perforated PVC sewer pipe and fittings and loose, bell-and-spigot joints.
 3. Transition to 6 inch solid wall PVC sewer pipe at point where radon and sub-slab ventilation pipe leaves the radon collection pit.
- B. Below Grade piping outside the radon collection pit and Above-grade Piping:
1. Solid-wall PVC sewer pipe and fittings and loose, bell-and-spigot joints.

3.4 RADON AND SUBSLAB VENTILATION PIPING

- A. Place impervious fill material on subgrade adjacent to bottom of slab after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches deep and 12 inches wide.
- B. Place impervious fill on subgrade adjacent to bottom of slab and compact to dimensions indicated, but not less than 6 inches deep and 12 inches wide after concrete footing forms have been removed.
- C. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- D. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to depth of not less than 4 inches. (Do not compact drainage layer).
- E. Install piping as indicated in Part 3 "Piping Installation" Article for radon and subslab ventilation piping.
- F. After satisfactory testing, cover piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.
- G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.

3.5 RADON AND SUBSLAB VENTILATION PIPING INSTALLATION

- A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.
- F. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- G. After satisfactory testing, cover piping with drainage course to elevation of bottom of slab, and compact and wrap top of course with flat-style geotextile filter fabric.
- H. Install horizontal drainage panels as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at inside edge of footings.
3. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

3.6 PIPING INSTALLATION

- A. Install piping beginning at points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves and couplings according to manufacturer's written instructions and other requirements indicated.
 1. Lay perforated pipe with perforations down.
- B. Use increasers, reducers and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install PVC piping according to ASTM D 2321.

3.7 PIPE JOINT CONSTRUCTION

- A. Join PVC pipe and fittings according to ASTM D 3034 with elastomeric seal gaskets according to ASTM D 2321.
- B. Join perforated PVC pipe and fittings according to ASTM D 2729, with loose bell-and-spigot joints.

3.8 RADON EXHAUST FAN AND PRESSURE SWITCH INSTALLATION

- A. Radon exhaust fan provision is not part of the Base Bid; radon fans shall be installed only if post-construction radon testing indicates that radon fans are required..
- B. Install radon exhaust piping pressure switch, in accessible location, in each radon vent riser (to roof penetration) according to manufacturer's best recommendations..
- C. Coordinate reservation of spare for wiring of fan (power) and coordinate wiring of pressure switch (to fire alarm system) with Electrical Contractor.

3.9 CONNECTIONS

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

3.10 IDENTIFICATION

- A. Materials and their installation are specified in Section 310220 "Building Earthwork". Arrange for installation of green warning tapes directly over piping.
 1. Install PE warning tape or detectable warning tape over ferrous piping.
 2. Install detectable warning tape over nonferrous piping and over edges of underground structures.

- B. Provide identification for radon exhaust piping and pressure switch alarm.

3.11 FIELD QUALITY CONTROL

- A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components and repeat test until results are satisfactory.
- B. After completion of Radon Mitigation system installation, obtain/pay for the services of a State-approved public school radon testing company to test for radon levels in areas of new and disturbed existing slab as described in Radon Subslab Depressurization Detail on Plumbing drawings. Advise Owner, Architect and Engineer of test results. If any areas test higher than actionable level of 4 picocuries/liter, radon mitigation fan serving that area shall be provided, wired turned on, and shall operate continuously, with signage posted at Radon Exhaust Fan stating "Fan Shall Run Continuously"..

3.12 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 312313

SECTION 31 2310 - EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Preparation and grading subgrades for slabs-on-grade, walks, pavements, and landscaping.
 - 2. Excavating and backfilling for structures.
 - 3. Excavation and backfilling for underground utilities and associated appurtenances.
 - 4. Excavation, backfill and compaction for the demolition/removal of subsurface utilities and improvements.
 - 5. Earth retention systems.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.
- C. Contractor is responsible for all health and safety.

1.2 GENERAL

- A. Contractor is advised that lines and grades, as shown on the Drawings, are subject to change. Although it is intended to adhere to what is shown on Drawings, Engineer reserves the right to make changes in lines and grades of utilities or other subsurface construction when such changes may be necessary or advantageous.
- B. In open trenching on public roadways, Contractor shall be governed by the conditions, restrictions and regulations made by the local or state authority as applicable. All such regulations shall be in addition to those set down in the Specifications.

1.3 EXCAVATION CLASSIFICATIONS

- A. Excavation - Excavation shall be unclassified and no consideration will be given to the nature of the materials. Excavation shall comprise and include the satisfactory removal and disposal of all materials encountered regardless of the nature of the materials and shall be understood to include but not limited to earth, fill, foundations, pavements, curbs, piping, railroad track and ties, cobblestones, footings, bricks, concrete, previously abandoned drainage structures and utility structures abandoned and not removed by the utility and debris.
- B. Rock Excavation - Rock shall be defined for payment purposes as stone or hard shale in original ledge, boulders over two (2) cubic yards in volume in open areas and one (1) cubic yard in volume in trenches, and masonry or concrete that cannot be broken or removed by normal job equipment (power shovels, scoops, or bulldozers with ripper attachment) without the use of explosives or drills. The classification does not include materials that can be removed by means other than drilling and blasting or drilling and wedging but which, for reasons of economy in excavating, the Contractor prefers to remove by drilling and blasting.

The word "trenches" shall mean excavation having vertical sides the depths of which exceed the width, made for drain, sewer, water, and gas pipes; electric and steam conduits; and the like.

1.4 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- C. Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction
- D. American Concrete Institute (ACI)
 - 1. ACI 229R-99 - Controlled Low-Strength Materials (CLSM).
- E. American Society for Testing and Materials (ASTM)
 - 1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.
 - 2. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³(2,700 kN-m/m³)).
 - 4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 5. AASTM D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
 - 7. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.5 DEFINITIONS

- A. Backfill: Soil material or flowable concrete used to fill an excavation.
- B. Bedding Course: Layer placed over the excavated sub-grade in a trench before laying pipe.
- C. Benching: A method of limiting cave-in potential by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

- D. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Clearing: Clearing shall consist in the felling, cutting up, and satisfactory disposal of trees and other vegetation designated for removal in accordance with these specifications.
- F. Drainage Course: Layer supporting basement grade used to minimize capillary flow of pore water.
- G. Earth Retention Systems: Any structural system, such as sheeting and bracing or cofferdams, designed to retain in-situ soils in place and prevent the collapse of the sides of an excavation in order to protect employees and adjacent structures.
- H. Excavation: Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.
 - 1. Additional Excavation: Excavation below subgrade elevations as directed by Architect. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Bulk Excavation: Excavations more than 10 feet in width and pits more than 30 feet in either length or width.
 - 3. Unauthorized Excavation: Excavation below sub-grade elevations or beyond indicated dimension without direction by Architect. Unauthorized excavation, as well as remedial Work directed by Architect, shall be without additional compensation.
- I. Fill: Soil materials used to raise existing grades.
- J. Finished Grade: The proposed final elevations shown on the Drawings or called for in the Specifications.
- K. Geotechnical Testing Agency: An independent testing agency, employed by the Owner and qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.
- L. Grubbing: Grubbing shall consist of the removal of roots 1 ½ inch and larger, organic matter and debris, and stumps having a diameter of three inches or larger, to a depth of at least 18 inches below the surface and or subgrade; whichever is lower, and the disposal thereof.
- M. Protective System: A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include earth retention systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.
- N. Regular Excavation: Removal and disposal of any and all material above subgrade elevation, except solid rock and undercut excavation, located within the limits of construction.
- O. Rock Excavation: Removal and satisfactory disposal of all unsuitable materials, which, in the opinion of Engineer, cannot be excavated except by drilling, wedging, jack hammering or hoe ramming. It shall consist of undecomposed stone, hard enough to ring under hammer. All boulders containing a volume of more than one-half cubic yard and/or solid ledges, bedded deposits, unstratified masses and conglomerations of material so firmly cemented as to possess the characteristics of solid rock which cannot be removed without systematic drilling or hoe ramming will be classified as rock.

- P. Licensed Professional Engineer: A person who is licensed as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.
- Q. Shield System: A structure that is designed to withstand the forces imposed on it by a cave-in and thereby protects employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either pre-manufactured or job-built in accordance with 29 CFR 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."
- R. Sloping: A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.
- S. 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.
- T. Sub-grade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below drainage fill.
- U. Surplus Material: Excavated acceptable material that cannot be utilized elsewhere on the site as backfill or embankment fill, or as otherwise directed by the Engineer.
- V. Temporary Dewatering System: A system to lower and control water to maintain stable, undisturbed subgrades at the lowest excavation levels. Dewatering shall be provided for all pipelines, structures and for all other miscellaneous excavations.
- W. Trench: A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet.
- X. Unacceptable Material: Soil material that contains organic silt, peat, vegetation, wood or roots, stones or rock fragments over six (6) inches in diameter or exceeding 40 percent by weight of the backfill material, porous biodegradable matter, loose or soft fill, construction debris, or refuse, or material which cannot be compacted to the specified or indicated density.

1.6 SAFETY

- A. Contractor shall conduct all excavation activities in conformance with applicable regulations, including those relating to warning signs, excavation safety, sheeting, shoring, and stabilization.
- B. Contractor shall provide and maintain barricades, signs, lights, etc., required for the protection of personnel, materials and property. Temporary barricades, etc. shall conform all applicable codes and regulations, and shall be lighted at night with lanterns, flares and reflectorized paint as required for safety. Adapt barricades, signs, lights, etc. to evolving site conditions throughout the progress of the work.

- C. Provide other safety devices as required, including adaptation of such safety devices to changing site conditions, to prevent unauthorized entry to construction areas and open excavations. Provide warning signs and other temporary construction safety devices necessary for proper completion of the work in compliance with applicable safety regulations.
- D. Contractor shall properly design and furnish all labor, materials, equipment, and tools necessary to completely construct the excavation support system, permanent or temporary, including sheet piling, trench shields, trench boxes, timber trench shoring, pneumatic/hydraulic shoring, steel sheeting or sheeting using other materials, sloping and benching. All of the proper materials and all equipment necessary to protect employees in excavations against cave-ins shall be furnished and installed.
- E. Any time an excavation is to remain open, at a minimum, provide full enclosure with safety barriers and fencing, warning signs, and additional safety control measures as appropriate.

1.7 SUBMITTALS

- A. Site Characterization of Off-Site Borrow Sources: The following information shall be submitted to Engineer for review at least two weeks prior to use of an off-site borrow source:
 - 1. Location and name of the borrow source site.
 - 2. Owner and contact information for the borrow source site.
 - 3. Present and past usage of the source site and materials.
 - 4. Any previously existing report(s) associated with an assessment of the source site as relates to the presence of oils, hazardous materials, or other organic and non-organic constituents which may be considered contaminants.
 - 5. Location within the site from which the material will be obtained.
 - 6. Chemical Testing Data: Analytical test results from a certified laboratory keyed to each type/classification of earth material proposed, along with written certification that proposed material is free of oils, hazardous materials, or other organic and non-organic constituents which may be considered contaminants.
 - 7. Chemical Testing Data: For each type/classification and source of earth material proposed, submit a letter signed by an authorized representative of Contractor stating that such proposed earth material is free of oils, hazardous materials, or other organic and non-organic constituents which may be considered contaminants.
- B. Material Testing Data
 - 1. Gradation analysis all proposed bedding, fill, aggregates, and backfill.
 - 2. Soil classification and Moisture-Dry Density Curve for all proposed bedding, fill, and backfill.
- C. Field Testing Results
 - 1. Compaction test results keyed to date and specific location of testing.

- D. Testing Entity: Submit the name and qualifications of third party testing entity, including the entity who will collect samples and the laboratory who will analyze samples, if different. Submit applicable documentation of credentials, licenses, etc.
- E. Product Data
 - 1. Plastic warning tape.
 - 2. Separation fabric, filter fabric, geogrids, or similar geotextiles.

1.8 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.
- B. Codes and Standards: Perform the work of this Section in accordance with all applicable codes, standards, and the requirements of authorities having jurisdiction.
- C. Engineer reserves the right to perform all in-field testing specified in this Section and reserves the right to determine the suitability of all materials to be used for fills and reject any fill not meeting the specifications.
- D. Field Density testing and subgrade observation shall be performed by the designated entity
- E. Weather Limitations:
 - 1. Material excavated when frozen or when air temperature is less than 32 degrees Fahrenheit (32 F) shall not be used as fill or backfill until material completely thaws.
 - 2. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.9 TESTING

- A. The Owner will retain a testing entity to perform observation and testing of the work under this Section. The testing entity's presence does not constitute supervision or direction of Contractor's work. Neither the presence of the testing entity nor any observations and testing performed by him, nor any notice or failure to give notice shall excuse Contractor from conformance with these Specifications or from defects discovered in his work.
- B. Borrow and Fill: Contractor shall provide testing as defined below.
 - 1. Gradation analysis for each type of borrow and on-site fill materials by ASTM D422.
 - 2. Soil classification (ASTM D2487) and Moisture-Dry Density Curve (Proctor Test-Modified) by ASTM D1557 for all proposed fill and backfill materials at the frequency specified below:
 - a. For suitable soil materials removed during Trench Excavation, perform one test for every 1,000 cubic yards of similar soil type. Similarity of soil types will be as determined by the Engineer.

- b. For borrow materials, perform tests from each proposed source, at a rate of one test for every 1,000 cubic yards of soil type. Similarity of soil types will be as determined by the Engineer.
- C. Compaction Testing: Owner will conduct compaction testing (i.e. ASTM D2922 and ASTM D3017 or ASTM D1556) at a frequency of one test for every 100 cubic yards of material backfilled.
 - 1. Additional compaction testing may be required when there is evidence of a change in the quality of moisture control or the effectiveness of compaction.
 - 2. If all compaction test results within the initial 25% of the total anticipated number of tests indicate compacted field densities equal to or greater than 95% of maximum dry density at optimum moisture content, Engineer may reduce frequency of compaction testing. In no case will the frequency be reduced to less than one test for every 500 cubic yards of material backfilled.
 - 3. If testing indicates that compacted subgrade, backfill, or fill are below specified density, additional compaction and/or replacement of material shall be provided at no expense to Owner.
- D. Chemical Testing: Prior to delivery of any earth material to the Project Site, Contractor shall conduct chemical testing to demonstrate that such material is free of oils, hazardous materials, or other organic and non-organic constituents which may be considered contaminants.

1.10 SEPARATION OF SURFACE MATERIALS

- A. When excavations are to be made in paved surfaces, the pavement shall be removed so as to provide a clean uniform edge with a minimum disturbance of remaining pavement. Saw cutting the pavement to provide a clean, uniform edge shall normally be required, unless otherwise approved in the Contract.
- B. If pavement is removed in large pieces, it shall not be mixed with other excavated material, but shall be disposed of away from the site of the Work before the remainder of the excavation is made.
- C. The attention of the Contractor is directed to the specifications for replacing pavement.

1.11 EXCAVATED MATERIAL

- A. Placement
 - 1. Excavated material shall be so placed as not to interfere with travel or movement on existing streets, driveways, sidewalks or other areas designated to remain undisturbed. Excavated material shall not be deposited on private property without the written consent of the property owner(s) and approval of Engineer.
 - 2. No excavated material shall be stored on top of installed pipe or other construction. Contractor shall consider surcharge loads when stockpiling excavated material adjacent to trenches, and take any measure required to prevent cave-in, including but not limited to, trench support systems and/or stockpiling excavated material remote from trench.

- B. No excavated materials shall be removed from the Project Site or disposed of by Contractor, except as approved by Engineer.
- C. Suitable excavated material may be used for Common Fill or Backfill on other parts of the Work, if specifically approved by Engineer.
- D. Material excavated from private property shall belong to the property Owner, or his representative, and shall be disposed of by the Contractor, as required by said Owner or his representative. If the Contractor fails to promptly remove such surplus material, Engineer may have the same done and charge the cost thereof as money paid to the Contractor.
- E. Contractor shall be responsible for the proper disposal of all unsuitable excavated materials. Engineer shall determine what is suitable or unsuitable material where questions arise. Generally, unsuitable material shall include, but not be limited to, pavement (bituminous and concrete), large boulders, pipe, conduit and metal.
- F. Contractor shall submit to Engineer, for approval, the location(s) to be utilized during the Contract period for waste material disposal. This approval must occur before any export of waste material from the project site. Any change in the disposal site during construction shall be submitted for approval.

1.12 SHEETING, SHORING AND BRACING

- A. Provide earth retention systems as required by federal, state and local regulations. Shoring and bracing of trenches and other excavations shall be in accordance with the latest OSHA Standards and Interpretations, and to all other applicable codes, rules and regulations of federal, state and local authorities.

1.13 DRAINAGE

- A. At all times during construction, Contractor shall temporarily provide, place and maintain ample means and devices with which to remove promptly, and dispose of properly, all water entering trenches and other excavations, or water that may flow along or across the site of the Work, and keep said excavations dry until the structures, pipes, and appurtenances to be built therein have been completed to such extent that they will not be damaged. At the conclusion of the work, Contractor shall remove such temporary means and devices.
- B. All groundwater which may be found in the trenches and foundation excavations, and any water which may get into them from any cause whatsoever, shall be pumped or bailed out, so that the trench shall be dry during pipe laying and backfilling and during the placement of concrete.
- C. All water pumped or drained from the Work shall be managed in accordance with applicable discharge permits, without undue interference with other work or damage to pavements, other surfaces, or property.

1.14 UTILITIES

- A. Prior to commencing earthwork operations, comply with utility mark-out requirements of the Call-Before-You-Dig System (1-800-922-4455).
 - 1. Confirm the location of all subsurface utilities marked through the Call-Before-You-Dig System.
 - 2. Not all subsurface facilities or structures will be identified through the Call-Before-You-Dig System. Confirm the location of other subsurface facilities or structures prior to commencing earthwork operations. Field-mark utilities as required.

1.15 COORDINATION

- A. Prior to commencing earthwork operations, meet with representatives of governing authorities, Engineer, testing entity, and other pertinent entities.
 - 1. Review earthwork procedures and responsibilities including Contractor's schedule of operations, scheduling observation and testing procedures and requirements.
 - 2. Notify participants at least three (3) working days prior to convening conference. Record discussions and agreements and furnish copies to each participant.
 - 3. Contractor shall at all times so conduct his work as to insure the least possible inconvenience to the general public and the residents in the vicinity of the work. Fire hydrants on or adjacent to the work shall be kept accessible to firefighting equipment at all times. Temporary provisions shall be made by Contractor to ensure the proper functioning of all gutters, sewer inlets, drainage ditches, and irrigation ditches, which shall not be obstructed except as approved by Engineer.
- B. Benchmark/Monument Protection: Protect and maintain benchmarks, monuments or other established reference points and property corners. If disturbed or destroyed, replace at no cost to Owner.
- C. Provide five (5) days advance notice to Engineer and testing entity for any proposed earthwork operation requiring observation and/or testing.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

- A. Satisfactory materials shall not contain shale, clay, ash, slag, friable material, organic or vegetative materials, topsoil, wood, trash, broken concrete, masonry rubble, trash, refuse, or frozen materials.
- B. Unsatisfactory Soils: Soil materials not meeting the requirements for Satisfactory Soils.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within two (2) percent of optimum moisture content at time of compaction.

2.2 COMMON FILL/ORDINARY BORROW

- A. Earth materials classified by ASTM D 2487 as GW, GP, GM, GP-GM, GW-GM, GP-GC, SW, SP, and SM that are free of clay.

- B. Common Fill material is subject to the approval of Engineer and may be either material removed from excavations or borrow from off site. It shall have physical properties such that it can be readily spread and after it has been placed and properly compacted, it will form a dense, stable fill.
- C. Common Fill shall be graded as follows:

Gradation of Common Fill

Sieve	Percent Passing by Weight
6"	100
3.5 "	50-100
3/4"	50-90
No. 4	25-55
No. 200	0-20

1. Less than twenty (20) percent of material by weight passing the No. 4 sieve shall pass the No. 200 sieve.
2. Common Fill shall not be used at locations where use of select fill is indicated.

2.3 PLAY AREA STONE BASE

- A. Granular material, well graded from fine to coarse, obtained from approved natural deposits and unprocessed, except for the removal of unacceptable material and stones larger than the maximum size permitted.
- B. Play Area Stone Base shall be graded as follows:

Gradation of Bank Run Gravel (ConnDOT Grading "C")

Sieve	Percent Passing by Weight
1 1/2"	100
3/4"	45-80
1/4"	25-60
No. 10	15-45
No. 40	5-25
No. 100	0-10
No. 200	0-5

2.4 GRANULAR FILL

- A. Broken or crushed stone, gravel, or a mixture thereof.
- B. Broken or crushed stone
1. The product resulting from the artificial crushing of rocks, boulders or large cobblestones, substantially all faces of which have resulted from the crushing operation. Broken or crushed stone shall consist of sound, tough, durable stone,

reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces.

C. Bank or crushed gravel

1. Sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. Crushed gravel shall be the manufactured product resulting from the deliberate mechanical crushing of gravel with at least 50% of the gravel retained on the No. 4 sieve having at least one fractured face.

D. Granular Fill shall be graded as follows:

Gradation of Granular Fill (ConnDOT Grading "A")

Sieve	Percent Passing by Weight
3 1/2"	100
1 1/2"	55-100
1/4"	25-60
No. 10	15-45
No. 40	5-25
No. 100	0-10
No. 200	0-5

2.5 SCREENED GRAVEL AND CRUSHED STONE

- A. Screened gravel, well graded in size from 3/8 inch to 3/4 inch. The gravel shall consist of clean, hard, and durable particles or fragments. Crushed rock of suitable size and grading may be used instead of screened gravel.

B. Screened Gravel shall be graded as follows:

Gradation of Screened Gravel (ConnDOT Gradation No. 6)

Sieve	Percent Passing by Weight
1"	100
3/4"	90-100
1/2"	20-55
3/8"	0-15
No. 4	0-5

2.6 SUBBASE

A. Bank or Crushed Gravel

1. Sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces. It shall be hard and durable enough to resist weathering, traffic abrasion and crushing.
2. Bank or crushed gravel for subbase shall be graded as follows:

Gradation of Bank or Crushed Gravel Subbase (ConnDOT Gradation "A")

Sieve	Percent Passing by Weight
3 1/2"	100
1 1/2"	55-100
1/4"	25-60
No. 10	15-45
No. 40	5-25
No. 100	0-10
No. 200	0-5

2.7 DYNAMIC STONE BASE (FOR PLAY FIELDS)

- A. Product resulting from the artificial crushing of rocks, boulders or large cobblestones, substantially all faces of which have resulted from the crushing operation. Material shall consist of sound, tough, durable, angular stones, reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud, dirt, organic matter, or other deleterious material. Material shall be double-washed.
1. Testing and evaluation of material by the testing laboratory shall evaluate material composition for the presents of appreciable amounts of feldspar or micaceous materials and note same on testing report. Material maybe rejected due to the presence of appreciable amounts of feldspar or micaceous materials.
- B. Test for Resistance to Abrasion, ASTM C131. Materials shall show a loss on abrasion of not more than 50%.
- C. Soundness, ASTM C88. Coarse aggregate shall not have a loss of more than 15% at the end of five cycles.
- D. Gradation:
1. Gradation of Stone

Sieve	Percent Passing by Weight
1"	100
3/4"	90-95
1/2"	55-90
3/8"	45-75
No. 4	32-52
No. 10	20-35
No. 16	15-27
No. 40	7-17
No. 100	2-8
No. 200	0-2
Silt or Clay	0

2.8 PROCESSED AGGREGATE BASE

- A. Coarse aggregates and fine aggregates shall be combined and mixed by approved methods so that the resulting material shall conform to the following gradation:

Gradation of Processed Aggregate Base

Sieve	Percent Passing by Weight
2 1/2"	100
2"	95-100
3/4"	50-75
1/4"	25-45
No. 40	5-20
No. 100	2-12

- B. Coarse Aggregate: Either gravel, broken stone or a combination thereof. When tested by means of the Los Angeles Machine, using AASHTO Method T 96, the coarse aggregate shall not have a loss of more than 50%.
1. If gravel is used for the coarse aggregate, it shall consist of sound, tough, durable particles of crushed or uncrushed gravel or a mixture thereof, free from soft, thin, elongated or laminated pieces, lumps of clay, loam and vegetable or other deleterious substances.
 2. If broken stone is used for the coarse aggregate, it shall consist of sound, tough, durable fragments of rock of uniform quality throughout. It shall be free from soft disintegrated pieces, mud, dirt, organic or other injurious material.
 3. Soundness for Gravel and Broken Stone: When tested by magnesium sulfate solution for soundness using AASHTO Method T 104, the coarse aggregate shall show a loss of not more than 15% at the end of 5 cycles.
- C. Fine Aggregate: Natural sand, stone sand, screenings or any combination thereof. The fine aggregate shall be limited to material 95% of which passes a No. 4 (4.75-mm) sieve having square openings and not more than 8% of which passes a No. 200 (75- μ m) sieve. The material shall be free from clay, loam and deleterious materials.
1. Plasticity: When natural sand is used, the fine aggregate shall conform to the following:
 - a. When the fraction of the dry sample passing the No. 100 mesh sieve is 4% or less by weight (mass), no plastic limit test will be made.
 - b. When the fraction of the dry sample passing the No. 100 mesh sieve is greater than 4% and not greater than 8% by weight (mass), that fraction shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.
 - c. When the fraction of the dry sample passing the No. 100 mesh sieve is greater than 8% by weight (mass), the sample will be washed; and the additional

material passing the No. 100 mesh sieve shall be determined by AASHTO Method T 146, except that the No. 100 mesh sieve will be substituted for the No. 40 mesh sieve where the latter is specified in AASHTO Method T 146. The combined materials that passed the No. 100 mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.

2. Plasticity: When screenings or any combination of screenings and natural sand or any combination of stone sand and natural sand are used, the following requirements shall apply:
 - a. When the fraction of the dry sample passing the No. 100 mesh sieve is 6% or less by weight (mass), no plastic limit test will be made.
 - b. When the fraction of the dry sample passing the No. 100 mesh sieve is greater than 6% and not greater than 10% by mass, that fraction shall not have sufficient plasticity to permit the performing of the plastic limit test, using AASHTO Method T 90.
 - c. When the fraction of the dry sample passing the No. 100 mesh sieve is greater than 10% by weight (mass), the sample shall be washed; and additional material passing the No. 100 mesh sieve shall be determined by AASHTO Method T 146, except that the No. 100 mesh sieve shall be substituted for the No. 40 mesh sieve where the latter is specified in AASHTO Method T 146. The combined materials that have passed the No. 100 mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.

2.9 BEDDING

A. Slabs on grade

1. Granular Fill unless otherwise indicated.

B. Utilities

1. Unless otherwise indicated, bedding shall consist of screened gravel, maximum size 3/4 inches and minimum size 3/8 inches.
2. Flexible Pipe: Unless otherwise indicated, ASTM D2321, bedding, haunching, and initial backfill material shall be placed in six-inch lifts and be Class IA, IB, or II embedment material unless otherwise approved by Engineer.
3. When clay, wet, soft or silty soil conditions prevail, 3/4-inch crushed stone shall be used for bedding of pipe.

2.10 SAND

- A. Sand shall consist of clean, hard, durable, uncoated particles of quartz or other rock. It shall not contain more than 3% of material finer than a #200 sieve.
- B. Organic Impurities: Fine aggregate subjected to the colorimetric test shall not produce a color darker than Gardner Color Standard No. 11, using AASHTO T 21. If the fine

aggregate fails to meet this requirement, the provisions of AASHTO M 6, Section 5.2, will govern.

- C. Sand shall be uniformly graded as follows:

Gradation of Sand

Sieve	Percent Passing by Weight
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

- D. The above gradation represents the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from any source. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample will be rejected.

2.11 FLOWABLE CONCRETE FILL/BACKFILL (FLOWFILL)

- A. Cementitious material, ACI 229R, comprised of cement, aggregates, fly ash, water, and admixtures, capable of being poured or pumped, self-leveling, self curing to specified strengths.
- B. Excavatable flowfill: Concrete strength shall be liquid enough to flow, be self-leveling and excavatable by hand methods. Unless otherwise specified, excavatable flowfill shall have a minimum 28 day compressive strength of 30 psi, and shall not exceed 100 psi.
- C. Non-excavatable flowable: Concrete strength shall be liquid enough to flow and be self-leveling and excavatable by machine equipment. Unless otherwise specified, non-excavatable flowfill shall have a minimum 28-day compressive strength of 125 psi, and shall not exceed 200 psi.

2.12 DETECTABLE WARNING TAPE

- A. Acid and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 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 as follows:
1. Red: Electric power lines, electric power conduits and other electric power facilities.
 2. Yellow: Gas, oil petroleum products, steam, compressed air, compressed gas and all other hazardous materials.

3. Blue: Water.
4. Orange: Communication lines or cables, including but not limited to telephone, fire signals, cable television, and electronic controls.
5. Green: Storm drainage and sanitary sewer systems, including force mains and other non-hazardous materials.
6. Brown: Chilled Water and Other.

PART 3 EXECUTION

3.1 PREPARATION

- A. Notify “Call-Before-You-Dig” to request a utility mark-out for the Project Site prior to any earth disturbance. Provide written confirmation to Engineer that such mark-out has been completed..
- B. Take precautions for preventing injuries to persons or damage to property in or about the work. Protect structures, utilities, sidewalks, pavements and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.
- C. Protect sub-grades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
- D. 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.

3.2 CLEARING AND GRUBBING

- A. Clear, grub, remove, and dispose of all vegetation and debris within the limits of construction, as designated on the plans or as required by Engineer. Contractor shall remove only those trees and shrubs absolutely necessary to allow for the construction. The work shall also include the preservation from injury or defacement of all vegetation or object designated to remain. Refer to Section 31 1100 – Clearing and Grubbing.

3.3 DEWATERING

- A. Comply with all applicable permit requirements.
- B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrade and from flooding Project site and surrounding area.
- C. Protect sub-grades 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 de-watering system to keep subgrades dry and convey ground water away from excavations.

3.4 EXCAVATION

- A. Dust Control: During the progress of the Work, Contractor shall conduct his operations and maintain the area of his activities in order to minimize the creation and dispersion of dust. Refer to Section 01 5714- Temporary Dust Control.
- B. Make excavations in such manner, and to such widths, as will give suitable room for building the structures or laying and joining pipe, but complying with the trench limits shown on the drawings; shall furnish and place all sheeting, bracing, and supports; and shall render the bottom of the excavation firm and dry, and in all respects, acceptable.
- C. Excavate to the exact elevations shown on the plans, or as directed by Engineer. If Contractor excavates below the elevations specified on the plans, he shall bring the excavation back to the proper elevation (except as hereinafter noted) by backfilling with Granular Fill and tamping to provide a compact base in accordance with the provisions specified herein.
 - 1. Any increase in cost resulting from backfilling, or increasing the size of the footings or foundations, because of over-excavation in depth, unless the over-excavation is at the direction of Engineer, shall be at Contractor's expense. Excavation and replacement with structural fill of any disturbed or softened materials below the bottom of footing, resulting from inadequate preparation, dewatering, or protection of the bearing surface, shall be at Contractor's expense.
- D. Excavations in natural soils will fall in OSHA Class B and will require sloping excavations, which are not shored and exceed five (5) feet in height, to be cut back to slopes less than 45 degrees from the horizontal.
- E. U-10 Field South of Building: If the subgrades are wet, a 12" lift of screened gravel/crushed stone shall be placed to provide a stable subgrade for heavy equipment. The embankment shall be carried up to within two (2) feet of the proposed final grade.
- F. Athletic Fields at South Portion of Site: To address wet conditions, a 12" lift of screened gravel/crushed stone shall be placed as an initial layer under controlled fill where the field is in a cut condition. Excavated soils which are wet shall not be used as fill material on site until they are dried.
- G. If utilities are to be laid in new embankments, or other new fill areas which are more than 12 inches deep below the invert of the pipe, the fill material shall be placed and properly compacted to final grade or to a height of at least 3 feet above the top elevation of the pipe, whichever is the lesser, before laying pipe. Particular care shall be taken to ensure maximum consolidation of material under the pipe location. The pipe trench shall then be excavated as though in undisturbed material.

3.5 TRENCH EXCAVATION

- A. In general, trenches shall be excavated to such depth as will provide a cover depth as indicated on the drawings from finished grade to the top of the pipe barrel. Deeper trenches shall be provided where necessary on account of the conformation of the ground and to permit the alignment of the pipe without undue deflection of joints.
- B. Trenches shall be excavated by hand or machinery to the width and depth indicated on the Drawings and specified herein. Depth shall account for thickness of the pipe and thickness

of bedding. All loose materials shall be removed from the bottom of the trench so that the bottom of the trench will be in an undisturbed condition.

- C. If in the opinion of Engineer, the material at or below the depth to which excavation for structures and pipes would normally be carried is unsuitable for foundation, it shall be removed to such widths and depths as directed and replaced with suitable material.
- D. Trench widths shall be 3 feet greater than the nominal inside diameter of pipe for such diameters of 36 inches or less. For diameters greater than 36 inches, the width shall be 4 feet greater than nominal inside diameter. Trench excavation for manholes, catch basins, drop inlets, etc. shall be two (2) feet outside the neat lines of the foundations. These limits may be adjusted for field conditions at the direction of Engineer.
- E. Bedding for pipe and utility structures will be as detailed on the Drawings.

3.6 APPROVAL OF SUBGRADE

- A. Notify Engineer and third-party testing entity when excavations have reached required sub-grade.
- B. If Engineer, or third-party testing entity determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Reconstruct sub-grades damaged by freezing temperatures, frost, rain, accumulated water or construction activities, as directed by Engineer.

3.7 PROTECTION OF EXISTING FEATURES

A. General

- 1. All existing pipes, poles, wires, fences, curbing, property-line markers, and other structures which, in the opinion of Engineer, must be preserved in place without being temporarily or permanently relocated, shall be carefully supported and protected from damage by Contractor.
- 2. As excavation approaches underground structures, digging by machinery shall be discontinued and the excavation shall be done by means of hand tools.

B. Pavements: On paved surfaces to remain, do not use or operate tractors, bulldozers, or other power-operated equipment, the treads or wheels of which are so shaped as to cut or otherwise damage such surfaces. All surfaces, which have been damaged by Contractor's operations, shall be restored to a condition at least equal to that in which they were found immediately prior to the beginning of operations. Suitable materials and methods shall be used for such restoration.

C. Utilities

- 1. Existing utilities remaining in service, including those remaining in service until after relocation, and relocated utilities shall be protected from damage. Before excavating near any existing utilities, notify the utility owner, coordinate protective work and comply with the utility owners' requirements.
- 2. Safeguard and protect from damage or movement any existing services, utilities and utility structures uncovered or encountered which are to remain in service.

3. All utility services shall be supported by suitable means so that the services shall not fail when tamping and settling occurs.
 4. Where known utilities are encountered, notify Engineer and document location and type of utility before proceeding with work in such area.
 5. When uncharted or incorrectly charted piping or utilities are encountered during excavation, stop work and notify Engineer immediately. Cooperate with the utility owners in maintaining their utilities in operation prior to resuming work.
- D. Retaining Structures: Provide bracing, shoring, sheeting, sheet piling, underpinning or other retaining structures necessary to guard against any movement or settlement of existing or new construction, utility systems, paving, or other improvements. Assume responsibility for the strength and adequacy of retaining structures, and for the safety and support of construction, utilities or paving, and for any movement, settlement or damage thereto. Retain the services of a licensed engineer as required to design bracing, shoring, sheeting, sheet piling, underpinning or other retaining structures.
- E. Replacement and Relocation
1. In case of damage, Contractor shall notify the appropriate party so that proper steps may be taken to repair any and all damage done. When the Owner does not wish to make the repairs themselves, all damage shall be repaired by Contractor, or, if not promptly done by him, Engineer may have the repairs made at the expense of Contractor.
 2. If certain existing structures are encountered that in the opinion of Engineer require temporary or permanent relocation or removal, Engineer may order in writing that Contractor undertake all or part of such work or to assist the Owner in performing such work. For such occurrences, Contractor shall be compensated as applicable, as extra work.
 - a. In removing existing structures, Contractor shall use care to avoid damage to the material, and Engineer shall include for payment only those new materials, which, in his judgment, are necessary to replace those unavoidably damaged.
 3. The structures to which the provisions of the preceding two paragraphs shall apply include structures which (1) are not indicated on the drawings or otherwise provided for, (2) encroach upon or are encountered near and substantially parallel to the edge of the excavation, and (3) in the opinion of Engineer will impede progress to such an extent that satisfactory construction cannot proceed until they have been changed in location, removed (to be later restored), or replaced. (See Item 3.19, "Sub-Surface Obstructions" also).

3.8 FILL AND BACKFILL

- A. Fill: Contractor shall remove loam and topsoil, loose vegetable matter, stumps, large roots, etc., from areas upon which embankments will be built or material will be placed for final grading. The subgrade shall be shaped as indicated on the drawings and shall be so prepared by forking, furrowing, or plowing that the first layer of the new material placed thereon, will be well bonded to it.

- B. Backfill: Common Fill material may be used as backfill when authorized by Engineer, if Contractor can achieve required minimum dry density after compaction. Backfilling shall be done as promptly as is consistent with non-injury to the pipe or structures, but no backfilling shall be done before Engineer gives permission. Where the trench is in a paved area, or an area to be paved, backfill shall be bank-run gravel as shown on the drawings.
- C. Frozen material shall not be placed in fill, nor shall fill be placed upon frozen material. Previously frozen material shall be removed, or shall be otherwise treated as required, before new fill is placed.
- D. After the subgrade has been prepared, fill material shall be placed thereon and built up in successive layers not exceeding twelve (12) inches until it has reached the required elevation.
 - 1. When gravel fill or other material is used for foundation of structures, it shall be spread in layers of uniform thickness not exceeding six (6) inches before compaction. Each spread layer shall be thoroughly compacted by means of suitable power-driven tampers or other power-driven equipment.
- E. Each layer of material shall be compacted by the use of approved rollers, or other approved means, so as to secure a dense, stable, and thoroughly compacted mass. At such points as cannot be reached by mobile mechanical equipment, or where such equipment is not permitted, the materials shall be thoroughly compacted by the use of suitable power-driven tampers.
- F. Previously placed or new materials shall be moistened by sprinkling, if required, to ensure proper bond and compaction. No compacting shall be done when the material is too wet, from either rain or application of water, to compact it properly. At such times the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compaction, or such other precautions shall be taken as may be necessary to obtain proper compaction.
- G. Compaction Density: Compaction density shall be expressed as a percentage of maximum dry density at optimum moisture content according to ASTM D 1557 Method C. Density indicated is minimum required.
 - 1. Under structures, building slabs, and steps: 95 %
 - 2. At building foundations: 95 %
 - 3. Utilities, below pipe centerline: 95%
 - 4. Utilities below unpaved surface, above pipe centerline: 92%
 - 5. Utilities below paved surface, above pipe centerline: 95%
 - 6. Embankments: 92%
 - 7. Landscaped areas: 90 %.
 - 8. Athletic fields and similar recreational fields: 93%
- H. Upon completion of filling and backfilling, the streets or property shall be cleaned, surplus material removed and the surfaces restored to the condition in which it was before ground

was broken. All materials left over in public roadways shall become the property of the Contractor. If the Contractor fails to promptly remove such surplus material, Engineer may have the same done, and charge the cost thereof as money paid to the Contractor.

3.9 BACKFILLING UTILITIES AROUND STRUCTURES

- A. No backfill shall be deposited against concrete until the concrete has obtained sufficient strength to withstand the earth pressure placed upon it and in no case less than seven days, nor before carrying out and satisfactorily completing the tests for watertight structures specified elsewhere. Compaction of backfill against concrete structures shall not be carried out by motorized equipment closer to the structure than the depth of the structure below grade.

3.10 BACKFILLING UTILITIES

- A. As soon as practical after utility has been placed into bedding and joints properly made, backfilling shall begin, and shall continue without delay.
- B. Placement of bedding over pipe prior to placement of backfill shall be as indicated on the Drawings. Hand-place bedding at the sides of the pipe and to the limits indicated on the Drawings over the pipe. Bedding placed over pipe shall be in 6-inch layers, leveled along the length and width of the trench and thoroughly compacted with approved tampers.
- C. Install warning tape twelve (12) inches to twenty-four (24) inches above the utility unless otherwise specified by the utility owner/operator.

3.11 BACKFILL AT BUILDINGS

- A. Prior to placing compacted granular fill, subgrade shall be compacted with at least four passes of a minimum 10-ton dynamic force vibratory roller. Soft or loose material evident during compaction shall be removed and replaced with granular fill.
- B. Backfill as soon as permanent work has been completed and footings, piers, foundation walls, etc., have attained sufficient set and strength.
 - 1. Remove shoring and bracing prior to backfilling.
 - 2. Place backfill in maximum uniform layers of 9"; in confined areas use 6" lifts. Do not allow levels of fill against concrete walls to differ by more than two feet on either side of walls unless walls are adequately braced or all floor framing is in place, up to and including grade level slabs.
- C. Bring backfill to sub-grade elevations. Slope backfill at exterior of building to drain water away from building.

3.12 SUBSURFACE OBSTRUCTIONS

- A. As a general rule, sub-surface obstructions encountered along the route of the pipeline shall be considered as follows:
 - 1. Crossing Obstruction: All pipes, conduits, wires, etc. of whatever nature whose centerline lies at an angle of 20 degrees or greater to the centerline of the pipe being installed shall be considered as crossing obstructions and shall be protected, or repaired or replaced if damaged, or relocated, all at no additional cost to the Owner.
 - 2. Interfering Obstructions: All pipes, conduits, wires, etc. of whatever nature whose centerline lies at an angle of less than 20 degrees, but more than 5 degrees to the centerline of the pipe being installed, shall be considered as interfering obstructions. Costs for supporting such obstructions in place during installation of the new pipe shall be paid for by the Owner. Costs for supporting interfering obstructions shall not be construed to include any costs for excavation. Repairing or replacing damaged interfering obstructions, or relocation shall be accomplished at no additional cost to the Owner.
 - 3. Parallel Obstructions: All pipes, conduits, wires, etc. of whatever nature whose centerline lies at an angle of 5 degrees or less, or is truly parallel and less than 0.5 feet offset from outside the normal trench limits, as specified in Subarticle 3.5 B. of this

Section, of the pipe being installed, shall be considered parallel obstructions. Costs for supporting such obstructions in place during installation of the new pipe, including excavation, may be paid for by the Owner, or Owner may elect to pay for the cost of replacing such obstructions. Should Owner first elect to pay the cost of supporting the obstruction and then elect to pay the cost of replacing the obstruction, approved costs for supporting the obstruction, including excavation, incurred prior to electing replacement costs shall also be paid. After Owner elects to pay replacement costs, only replacement costs will be paid for all additional work in the vicinity of the parallel obstruction.

4. Angle measurement between centerline of obstructing pipe, conduit, wire, etc. and centerline of the pipe being installed shall be taken from between the horizontal projection of the centerlines at ground surface. Parallel offset distance between centerline of obstructing pipe, conduit, wire, etc. and the outside of normal trench limits of the pipe being installed shall be taken from between the horizontal projection of the centerlines and outside trench limit at ground surface.

END OF SECTION

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August 29, 2013

Mr. Peter R. Williams
Permanent School Building Committee
55 Main Street, P.O. Box 187
Ellington, CT 06029

**Re: Geotechnical Study for Proposed Addition/Alterations at Crystal Lake Elementary School,
284 Sandy Beach Road; Ellington, CT**

Dear Mr. Williams:

1.0 Herewith are the boring data pertaining to the above. Fifteen borings were drilled at the proposed building addition and contiguous site improvement to a maximum depth of 25.6 feet below the existing grades. The borings were drilled to at least 10 feet into competent bearing strata, to a minimum depth of 20 feet below the existing grades, or to auger refusal if above 20 feet. In addition to the borings three test pits, which were excavated by the Town of Ellington, were inspected and logged. The data from the test pits are included in the appendix. The boring locations were staked in the field by the Town of Ellington and are shown on the attached plan. *The borings were drilled by Clarence Welti Associates, Inc. and sampling was conducted by this firm solely to obtain indications of subsurface conditions as part of a geotechnical exploration program. No services were performed to evaluate subsurface environmental conditions.*

1.1 Laboratory testing included ten grain size gradation and water content tests on selected soil samples. The results of those tests are included in the appendix.

2.0 The Subject Project will include the construction a one story slab on grade building with a footprint of about 14,500 sf. The building will have a main floor level at Elev. 682.09. The floor level will step up where the addition connects to the existing building. The west wing of the existing building has a floor level at Elev. 684.09 and the east wing has a floor level at Elev. 686.71. In addition to the proposed building addition there will be two new athletic fields, a new access road from South Road, plus new and reconfigured roadways and parking around the site.

2.1 The existing grades at the proposed building addition range from about Elev. 670 to Elev. 684. The new access road from South Road will have about 15 feet of relief (from Elev. 668± at South Road to Elev. 683 at the school. The reconfigured parking and access driveways north of the school will be close to existing grade. The proposed parking new areas and access drives to the south and

west of the proposed building addition will require fills up to 12± feet and cuts up to 3± feet.

2.1.1 The **proposed new athletic field** immediately to the south of the school has about 8 feet of topographic relief (Elev.684 to Elev.676). The proposed grading for the field will require fills up to 5± feet and cuts up to 2± feet. The proposed field at the southwest corner of the site has about 25 feet of relief (Elev. 695 to Elev. 670). The proposed grading will require cuts up 10± feet and fills up to 6± feet. There will be about 315 lf of retaining wall, with a retained soil height up to 10± feet, located along the south side of the field. Based on the borings the field sub grades will be on a saturated silty moraine deposits. These soils will be sensitive to remodeling beneath equipment. This condition is discussed further herein with recommendations for earthwork on the site.

3.0 The **Geologic Origin** of the natural inorganic soils is from glacial moraine deposits. The moraine consists of fine to medium sand with little to some silt and gravel.

3.1 The **Soils Cross Sections** from the borings are generally as follows:

Proposed Building Addition (see borings B-3 thru B-8)

Topsoil to 6" to 8"

Locally FILL (see boring B-5); fine to medium SAND, some Silt, little Gravel, medium compact
Note: There will be fills adjacent to the existing building and utilities.

Fine to medium SAND, some Silt, trace Gravel to 2 to 3 feet, loose to medium compact

Fine to medium SAND, some Silt, trace Gravel 5 about 10 feet, dense

Fine to medium SAND, little to some Silt, trace Gravel and Cobbles to auger refusal at 14 to 21.5+ feet, dense to very dense

Ground water, where evident in the boreholes, was at 9 to 17 feet below the existing grades at the completion of the borings (Elev.661 to Elev.665). Water contents at boring B-3 indicated saturated soil at 4 feet below grade, but the water table was generally below 10 feet below grade at completion of the borings. Based on sample water contents, wet season water tables could be within 8 feet of the existing grade.

Parking Area and Roadway at North End (see boring B-1) in Existing Parking Area

Bituminous Concrete to 2.5"

Fine to coarse SAND, little Gravel, little Silt to 12", dense

Fine to medium SAND, little Silt and Gravel to 3 feet, dense

Fine to medium SAND, some Silt, trace Gravel, few Cobbles to 20+ feet, very dense

Ground water was not apparent at boring completion and on inspection of soil samples

Access Road from South Road to School (see Test Pits TP-1 and TP-2 & Boring B-2)

At tests pits; Topsoil to 12" to 24"

Subsoil; fine SAND and SILT, trace Roots, Gravel and Cobbles to 3 to 3.5 feet, loose/soft

Fine to medium SAND, little to some Silt and Gravel to bottom of test pit at 8 to 8.5 feet

The soil at test pit TP-2 was saturated below 6 feet and the **ground water** near South Road will be within 4 feet of grade in wet seasons.

At boring B-2; Topsoil to 7" atop fine to medium SAND, some Silt, trace Gravel to 21.5+ feet (no evident ground water)

Parking and Playground Areas to South of Building Addition (see borings B-4, B-6 and B-9)

Topsoil 6" to 8"

Locally Possible FILL or disturbed soils (see boring B-9); fine to medium SAND, some Silt, trace Gravel, loose to medium compact

Fine to medium SAND, some Silt, trace Gravel to 5 to 10 feet, medium compact to dense

Fine to medium SAND, little to some Silt, trace to little Gravel, few Cobbles to 20+ feet, dense to very dense

Ground water was at 11 feet below the existing grade at the completion of boring B-9 (Elev.667). Inspection of soil samples indicate the water table will be within 8 feet of grade in wet seasons.

The area to the east of the school is an existing paved lot with 2" of Bituminous Concrete on Sand and Gravel with little Silt to about 2 feet below grade (based on boring B-15)

Athletic Field East of Parking Area (see borings B-9 and B-10)

Topsoil to 6" to 9"

At boring B-9; fine to medium SAND, some Silt, trace Gravel; loose to medium compact

At boring B-10; fine to medium SAND, little Silt 5.5 feet, loose to medium compact

Fine to medium to fine to coarse SAND, little to some Silt, trace to little Gravel to 20+ feet, dense to very dense

Ground water was 6.5 to 11 feet below the existing grades at the completion of the borings (Elev.667 to Elev.670). There will be saturated soils due to capillary water to 2+ feet above the hydrostatic levels.

Possible Athletic Field Area (see borings B-11 and B-12)

Topsoil 6" to 8"

Subsoil; fine medium SAND, some Silt, trace Gravel, trace Roots to about 2 feet, loose

Fine to coarse SAND, some Silt, trace Gravel, few Cobbles auger refusal to 14 to 22.5 feet, dense to very dense

Ground water was at about 4 feet below grade and there may be capillary water above this level.

Southwest Athletic Fields (see borings B-13 and B-14 + Test Pit TP-3)

Topsoil 4" to 12"

Locally Fill; fine to coarse SAND, little Silt, trace Asphalt to 1.5 feet below grade

Subsoil (see TP 3); fine to medium SAND, some Silt, trace Roots to 2 feet, loose

Fine to medium SAND, some Silt, trace to little Gravel, medium compact to dense to about 10 feet below grade

Fine to medium SAND, some Silt, little Gravel, few Cobbles and Boulders to 20+ feet, very dense

Ground water was 3 to 8 feet below grade below the existing grades at the completion of borings and test pit (Elev.681 to Elev.667) .

4.0 The Criteria for Foundation Type and Loading are as follows:

1. The maximum total settlement shall not exceed 3/4" and the maximum differential settlement shall not exceed 1/2 the maximum settlement.
2. The Foundations and Structures must address the seismic section of the building code
3. The Slab at Grade floors must not settle differentially more than 1/2" in excess of the structure subsidence.

4.1 Regarding item 2 (above), the seismic site soil profile classification can be “C”. The mapped MCE spectral response acceleration values for Ellington, CT are $S_1 = 0.064$ for one second period and $S_s = 0.233$ for short period. For transfer of ground shear into the soil the ultimate friction factor should be **0.50**.

5.0 Regarding **Foundation Type**, the building can be supported on spread footings. The footings can be on the natural inorganic soils with the required sub grade preparation, or on a controlled fill placed after the removal of any topsoil, subsoils and existing fills. The natural soils are compact, but may be sensitive to remodeling beneath equipment when wet. To address this condition there shall be a minimum of 6" of crushed 3/8" stone beneath footings which are on the natural soils and as an initial layer beneath controlled fills which are atop a wet sub grade. Controlled fills shall conform to section 6.0 below and shall be extended laterally outside foundation for a distance equal to at least the depth of fill below the footings.

5.1 The **Allowable Bearing Pressure** for spread footings on crushed stone atop the natural inorganic soils or on the controlled fill can be 4,000 psf. At retaining walls the maximum pressure on the toe can be 50% higher than the average pressures, cited above.

5.2 The **Lateral Soil Loading** (static) on retaining walls that are part of the building shall be based on at-rest pressure using the at-rest coefficient cited in the table below. Lateral soil loading on retaining walls apart from the building can be designed with active pressure using the coefficient cited below for level backfill. The backfill for the walls shall conform to the material specification of section 6.0 below and shall extend laterally behind the walls for a distance equal to at least the wall height measured from footing bottom to finished grade. The ultimate sliding coefficient for concrete on the soil or crushed stone underlayment is **0.60**. **Lateral loading on retaining walls apart from the building can be designed with active pressure**

5.3 The **Frost Protection Depth** is 3.5 feet below finish grades in areas, which are exposed to weather.

5.4 Summary of Foundation Design Parameters:

Parameter	Value
Allowable Bearing Pressure for footings with preparation per section 5.0 above	4,000 psf
Soil Unit Weight (Backfill) *	120 pcf
Internal Friction Angle (Backfill) *	34°
At-Rest Pressure Coefficient, K_0	0.45
Active Pressure Coefficient, K_A (level backfill)	0.28

Ultimate Sliding Coefficient, concrete on crushed stone over soil	0.60
Seismic Site Soil Profile Classification	C
Mapped MCE Spectral Response Acceleration for one second period, S_1	0.064
Mapped MCE Spectral Response Acceleration for short period, S_s	0.233
Frost Protection Depth	3.5 feet

* Backfill material conforming to section 6.0 below

6.0 Regarding Controlled Fill, Backfill for Retaining Walls and Excavations at Columns and Walls, plus Slab at Grade Underlayment (to 4" below the slab bottom) the material shall conform to the following or be 3/8" crushed stone:

Percent Passing	Sieve Size
100	3.5"
50 - 100	3/4"
25 - 75	No.4

The fraction, passing the No.4 sieve shall have less than 15%, passing the No. 200 sieve.

The on site soils will generally not conform to the above gradation.

All backfill and fill must be compacted to at least 95% of modified optimum density.

6.1 There should be at least 16" of controlled fill, conforming to section 6.0 above, placed beneath slabs on grade. The final 4" layer directly beneath slab on grade floor slabs shall be with 3/8" crushed stone or 3/4" minus processed stone base. All existing fills (if any) and topsoil shall be removed beneath the floors. If the floor subgrades fall on wet soils, there will be a requirement for placement of a minimum 6" layer of 3/8" crushed stone over the sub grade prior to placing the controlled fill. A vapor retarder is required beneath the slab on grade floors.

7.0 Regarding Earthwork, excavations in the natural soils will fall in OSHA Class B. This will require sloping excavations, which are not shored and exceed 5 feet in height, to be cut back to slopes less than 45° from the horizontal.

7.1 Long Term Slopes in earth cuts and fills shall be 2:1, or flatter.

8.0 Regarding New Pavements, the sub grades will in most cases fall on frost susceptible moraine. There should be least 10" of material (subbase) conforming to section 6.0 above placed beneath the pavement sections. The recommended pavement sections above the subbase are as follows:

For passenger car parking: 3.0" bituminous concrete (two lifts) on 6" of processed stone base over gravel subbase

For bus and truck access areas: 4.5" bituminous concrete (two lifts) on 8" of processed stone base

There should be at 24" of material conforming to the gradation in section 6.0 above placed beneath Concrete Pavements which are in close proximity to the building.

8.0.1 Where pavements are in cuts there shall be edge drains, placed at 12" below the bottom of the subbase and backfilled with 3/8" crushed stone. In addition there shall be an under drain in the middle of the parking areas.

8.0.2 Regarding the access road from South Road, part of the embankment near Route 30 may be over a wet sub grade. There shall be a minimum 12" layer of 3/8" crushed stone as an initial layer beneath the embankment. Where the roadway in a cut section there shall be edge drains. Cut slopes higher than 4 feet will require stone wedges tied to the drains. Controlled fills for the roadway and parking lot embankments, to the bottom of the subbase, should conform generally to section 6.0 above.

8.1 For Portland Cement Concrete the concrete thickness for buses and light truck traffic would be 6". This would be placed on 12" of gravel subbase.

9.0 Regarding treatment in Athletic Fields there is at least 8± feet of topographic relief across each of the field footprints.

9.1 The proposed field located immediately to the south of the addition can be excavated and filled after stripping topsoil, largely with on site soils. If the sub grades are wet, it may necessary wet to place an initial 12" lift of 3/8" crushed stone to exclude capillary water migration into the controlled embankment and to provide a stable sub grade for heavy equipment. The embankment shall be carried up to within 2 feet of the proposed field grade and the excavation at the east end shall be cut to 2 feet below the finished grade. The material to the bottom of the top soil shall conform to the gradation in section 6.0 above . There shall be under drains in the section of field in a cut and possibly a separate under drain system, if the field is irrigated.

9.2 At the proposed fields located at the southwest corner of the site there is about 25 feet of topographic relief (Elev.670 to Elev.695). The proposed field grades will range from about Elev.678 to Elev.674. The proposed grading will require cuts 12± feet to the field sub grade elevation. Based on the borings and test pits taken in this area (see boring B-13, B-14 & TP-3), the sub grades in the cut areas will be on dense silty moraine deposits. The water table in the borings and test pit ranged from 3 to 8 feet below the existing grades. It should be assumed that the water table could be 2 feet

above those levels and that the soils to 2 feet above the water table will have water contents close to saturation. The moraine soils will be sensitive to remodeling beneath equipment when wet. To address this condition there should be a minimum 12" layer of 3/8" crushed stone as an initial layer beneath controlled fills and beneath the field where in a cut section. The placement of the crushed stone as an initial step will mitigate possible over excavation of soils which are disturbed as result of heavy equipment traffic over the wet subgrades. The soils which are taken from the cut area within 2 feet of the water table should not be used in fill areas beneath the field, unless they can be dried. It is recommended that an under drain be placed at the south side of the field as an initial step, prior to making the cuts for the field, to permit a lowering of the water table in that area. An under drain is required behind the site retaining wall.

10.0 This report has been prepared for specific application to the subject project in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made. In the event that any changes in the nature, design and location of structures are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing.

The analyses and recommendations submitted in this report are based in part upon data obtained from referenced explorations. The extent of variations between explorations may not become evident until construction. If variations then appear evident, it will be necessary to re-evaluate the recommendations of this report.

Dr. Clarence Welti, P.E., P.C., should perform a general review of the final design and specifications in order that geotechnical design recommendations may be properly interpreted and implemented as they were intended.

Very truly yours,



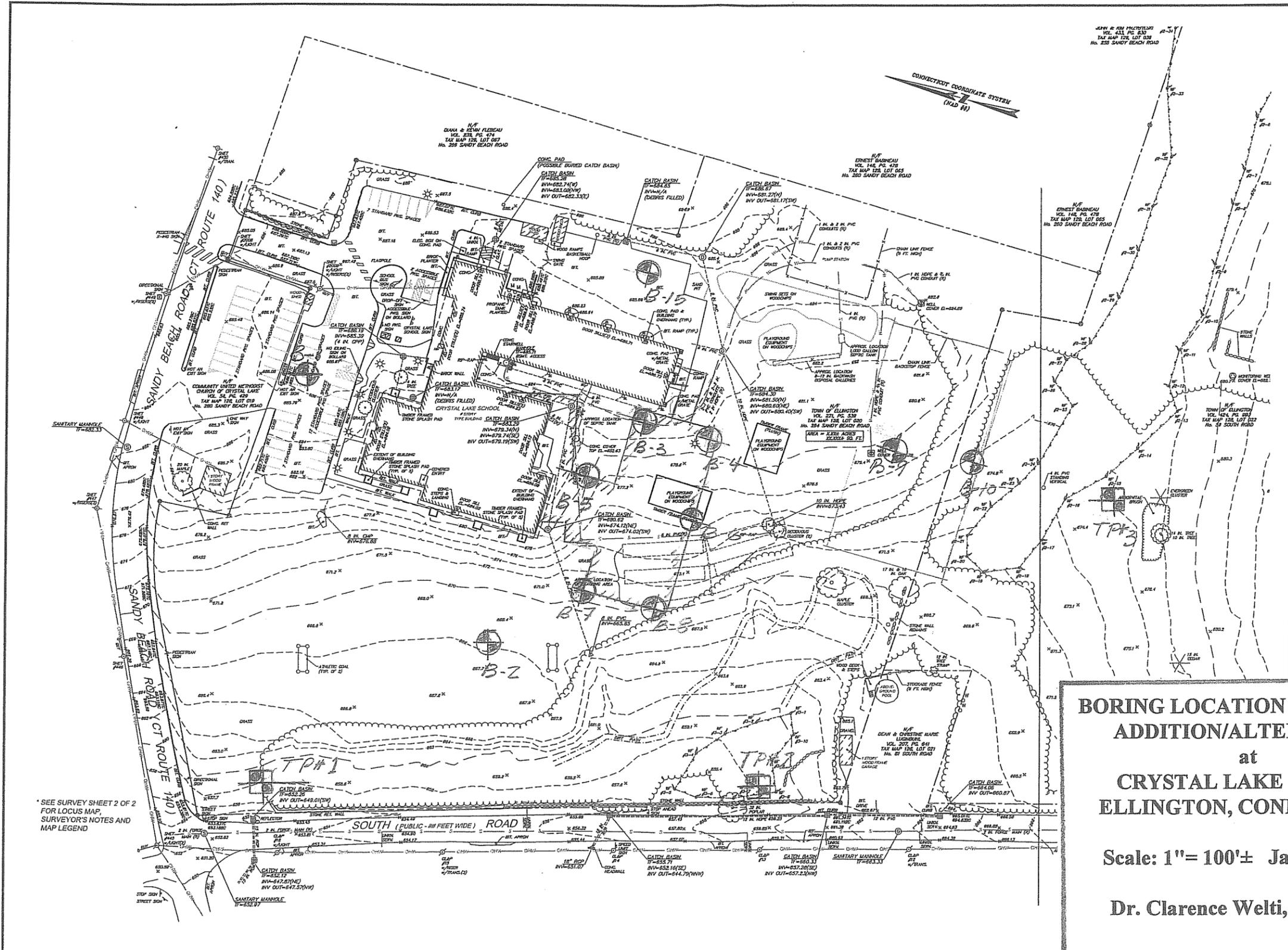
Max Welti, P.E.



Clarence Welti Ph.D., P. E.
President, Dr. Clarence Welti P.E.; P.C.

APPENDIX

BORING LOCATION PLAN
+
TEST BORING & TEST PIT LOGS
+
LABORATORY TEST RESULTS



REPRODUCTIONS OF THIS PLAN ARE INVALID UNLESS THEY BEAR THE EMBOSSED SEAL OF THE UNDERSIGNED PROFESSIONAL.

TO MY KNOWLEDGE AND BELIEF, THIS MAP IS SUBSTANTIALLY CORRECT AS NOTED HEREON.

KENNETH J. COOPER, L.S. No. 70047

LIMITED PROPERTY SURVEY OF THE CRYSTAL LAKE SCHOOL

LANDS OWNED BY THE TOWN OF ELLINGTON
SITUATED IN THE TOWN OF ELLINGTON, COUNTY OF TOLLAND, STATE OF CONNECTICUT

NOVEMBER 21, 2012

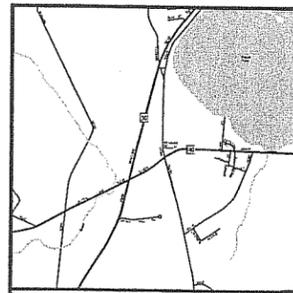
REVISIONS:

NO.	DATE	DESC.

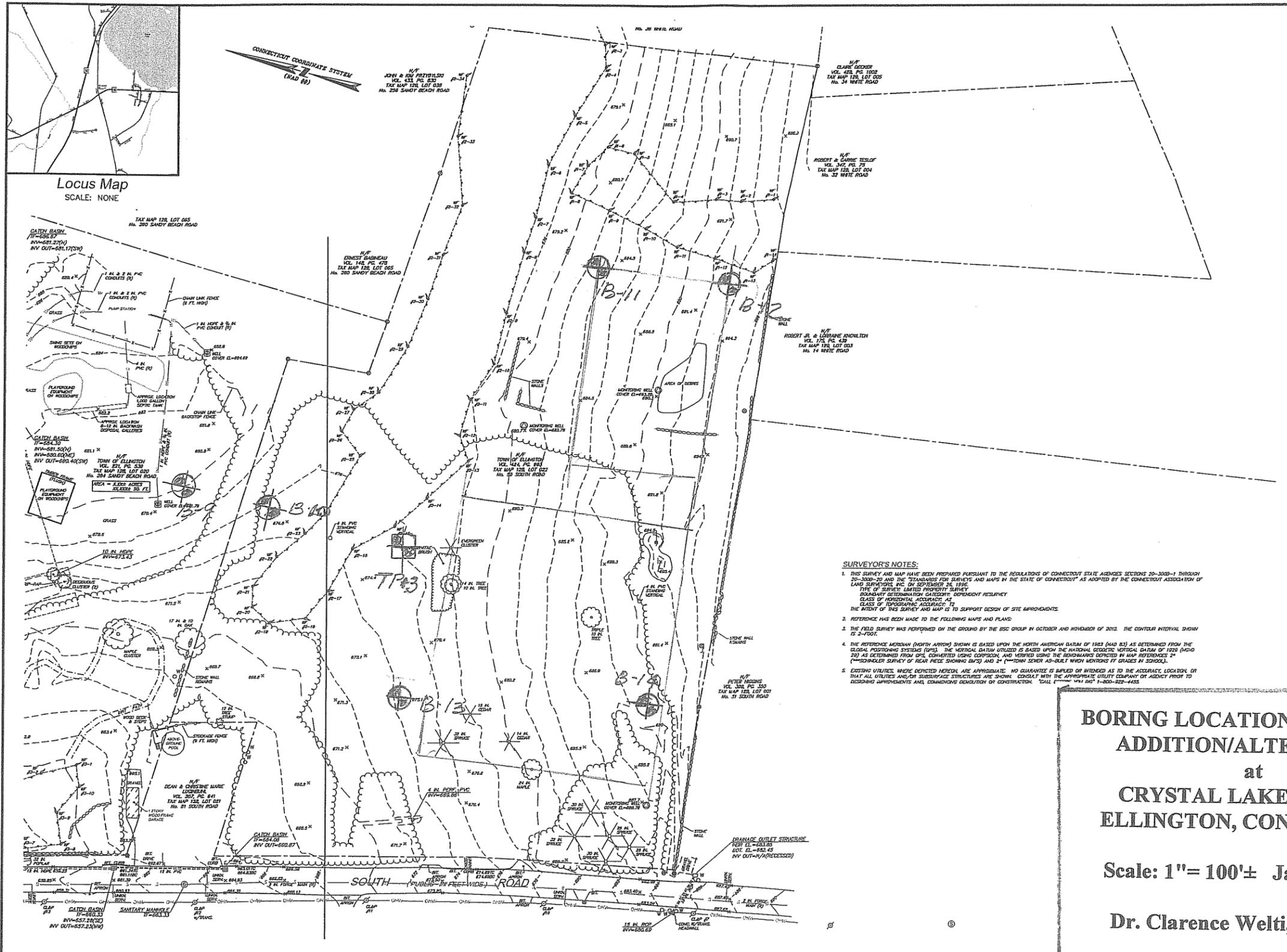
BORING LOCATION PLAN (1 of 2)
ADDITION/ALTERATIONS
at
CRYSTAL LAKE SCHOOL
ELLINGTON, CONNECTICUT
Scale: 1"= 100'± January 2013
Dr. Clarence Welti, P. E., P. C

* SEE SURVEY SHEET 2 OF 2 FOR LOCUS MAP, SURVEYOR'S NOTES AND MAP LEGEND

1/2/13



Locus Map
SCALE: NONE



SURVEYOR'S NOTES:

1. THIS SURVEY AND MAP HAVE BEEN PREPARED PURSUANT TO THE REGULATIONS OF CONNECTICUT STATE AGENCIES SECTIONS 20-202B-1 THROUGH 20-202B-20 AND THE STANDARDS FOR SURVEYS AND MAPS IN THE STATE OF CONNECTICUT AS ADOPTED BY THE CONNECTICUT ASSOCIATION OF LAND SURVEYORS, INC. ON SEPTEMBER 26, 1995.
TYPE OF SURVEY: LIMITED PROPERTY SURVEY
STANDARD OF ACCURACY: HORIZONTAL ACCURACY: 1/4" (CONSIDERABLE SURVEY) VERTICAL ACCURACY: 1/8" (CONSIDERABLE SURVEY)
THE INTENT OF THIS SURVEY AND MAP IS TO SUPPORT DESIGN OF SITE IMPROVEMENTS.
2. REFERENCE HAS BEEN MADE TO THE FOLLOWING MAPS AND PLANS:
A. THE FIELD SURVEY WAS PERFORMED ON THE GROUND BY THE BSC GROUP IN OCTOBER AND NOVEMBER OF 2012. THE CONTAINER INTERVAL SHOWN IS 2'-FOOT.
3. THE REFERENCE MERIDIAN (NORTH ARROW) SHOWN IS BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD 83) AS DETERMINED FROM THE GLOBAL POSITIONING SYSTEMS (GPS). THE VERTICAL DATUM UTILIZED IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29) AS DETERMINED FROM GPS, CORRECTED USING CORRECTION, AND VERIFIED USING THE BENCHMARKS DEPICTED IN MAP REFERENCES 2" (CONSIDERABLE SURVEY) OF REAR THESE SHOWING (B-13) AND 2" (TYPICAL) SEVERAL AS-BUILT WHICH MONITORS BY GRADES BY SURVEYOR.
4. EXISTING UTILITIES, WHERE DEPICTED HEREON, ARE APPROXIMATE. NO WARRANTY IS MADE BY WITNESSES AS TO THE ACCURACY, LOCATION, OR THAT ALL UTILITIES AND/OR SUBSURFACE STRUCTURES ARE SHOWN. CONSULT WITH THE APPROPRIATE UTILITY COMPANY OR AGENCY PRIOR TO BEGINNING IMPROVEMENTS AND COMMENCING DEMOLITION OR CONSTRUCTION. "CALL BEFORE YOU DIG" 1-800-522-4455.

REPRODUCTIONS OF THIS PLAN ARE INVALID UNLESS THEY BEAR THE EMBOSSED SEAL OF THE UNDERSIGNED PROFESSIONAL.

TO MY KNOWLEDGE AND BELIEF, THIS MAP IS SUBSTANTIALLY CORRECT AS NOTED HEREON.

KENNETH J. COOPER, L.S. No. 70047

LIMITED PROPERTY SURVEY
OF
THE CRYSTAL LAKE SCHOOL

LANDS OWNED BY
THE TOWN OF
ELLINGTON

SITUATED IN THE
TOWN OF ELLINGTON,
COUNTY OF TOLLAND,
STATE OF CONNECTICUT

NOVEMBER 21, 2012

REVISIONS:

NO.	DATE	DESC.

**BORING LOCATION PLAN (2 of 2)
ADDITION/ALTERATIONS
at
CRYSTAL LAKE SCHOOL
ELLINGTON, CONNECTICUT**

Scale: 1" = 100'± January 2013

Dr. Clarence Welti, P. E., P. C.

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 686.7	HOLE NO. B-1
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0					ASPHALT 0.17		
	1	7-10-28-24	1.00'-3.00'		BR.FINE-CRS.SAND, LITTLE SILT, TRACE GRAVEL 1.0	685	
					GREY FINE-MED.SAND, LITTLE SILT & GRAVEL		
	2	35-60	3.00'-4.00'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES 3.0		
5	3	16-22-17-32	5.00'-7.00'			680	
10	4	60	10.00'-10.42'			675	
15	5	48-60	15.00'-16.00'			670	
20	6	60	20.00'-20.08'		BOTTOM OF BORING @ 20.1' 20.1	665	
25						660	
30						655	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-1

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 668.5	HOLE NO. B-2
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	2-5-7-15	0.00'-2.00'		TOPSOIL	0.56	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	1.5	
	2	18-23-40-48	2.00'-4.00'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES		
5	3	18-21-27-47	4.00'-6.00'			665	
						660	
10	4	60	10.00'-10.50'			655	
						650	
15	5	60	15.00'-15.25'			645	
						640	
20	6	22-33-36	20.00'-21.50'			635	
					BOTTOM OF BORING @ 21.5'	21.5	
25						645	
						640	
30						635	
						635	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-2

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 682.5	HOLE NO. B-3
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 17.0 FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	7-13-14-22	0.00'-2.00'		TOPSOIL	0.50	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	1.0	
5	2	12-10-11-12	2.00'-4.00'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	680	
	3	10-12-11-60	4.00'-5.83'				
10						675	
	4	11-16-25	10.00'-11.50'				
15						670	
	5	60	15.00'-15.50'				
20						665	
	6	35-60	20.00'-20.92'				
25					BOTTOM OF BORING @ 20.9	20.9	
30						660	
35						655	
						650	
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-3

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 681.0	HOLE NO. B-4
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	2-5-6-5	0.00'-2.00'		TOPSOIL	680	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	0.50	
	2	4-5-6-8	2.00'-4.00'		GREY/BR.FINE-CRS.SAND, SOME SILT, LITTLE GRAVEL	2.0	
5	3	10-13-11-11	4.00'-5.83'			675	
					GREY/BR.FINE-CRS.SAND, LITTLE SILT & GRAVEL	8.0	
10	4	17-60	10.00'-10.83'			670	
15	5	27-60	15.00'-15.92'			665	
					GREY/BR.FINE-MED.SAND, SOME SILT	18.0	
20	6	21-42-60	20.00'-21.17'			660	
					BOTTOM OF BORING @ 21.2	21.2	
25						655	
30						650	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-4

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT TOWN OF ELLINGTON		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
						LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 678.5	HOLE NO. B-5
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	3-11-13-14	0.00'-2.00'		TOPSOIL	0.66	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL - FILL		
	2	12-15-25-40	2.00'-4.00'			3.0	
					RED/BR.FINE-MED.SAND, SOME SILT, LITTLE GRAVEL - FILL		
5	3	27-30-60	4.00'-5.50'			5.0	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL		
						670	
10	4	17-29-39	10.00'-11.50'		GERY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	10.0	
						665	
15					BOTTOM OF BORING @ 14.0' (AUGER REFUSAL)	14.0	
						660	
20						655	
25						650	
30						645	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-5

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 676.0	HOLE NO. B-6
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	3-7-8-5	0.00'-2.00'		TOPSOIL		
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	0.66	
	2	14-13-27-30	2.00'-4.00'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL	2.5	
5	3	25-20-32-25	4.00'-5.83'				
						670	
10	4	60	10.00'-10.25'		GREY/BR.FINE-MED.SAND, LITTLE SILT & GRAVEL, FEW COBBLES	10.0	
						665	
15	5	60	15.00'-15.50'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	15.0	
						660	
20	6	60	20.00'-20.50'		BOTTOM OF BORING @ 20.5'	20.5	
						655	
25						650	
30						645	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-6

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 672.0	HOLE NO. B-7
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 9.0 FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	3-3-7-12-15	0.00'-2.00'		TOPSOIL	0.56	
					BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL		
	2	13-17-15-22	2.00'-4.00'		GREY/BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	1.5	
						670	
5	3	17-17-60	4.00'-5.25'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	4.5	
						665	
10	4	31-40-44	10.00'-11.50'				
						660	
15	5	43-55-60	15.00'-16.50'				
						655	
20	6	60	20.00'-20.50'		BOTTOM OF BORING @ 20.5'	20.5	
						650	
25							
						645	
30							
						640	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-7

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 678.0	HOLE NO. B-9
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 11.0 FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	3-2-3-2	0.00'-2.00'		TOPSOIL BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLE - POSSIBLE FILL OR DISTURBED SOILS	0.50	
	2	1-2-7-7	2.00'-4.00'			675	
5	3	1-2-7-15	5.00'-7.00'		GREY/BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	5.0	
						670	
10	4	60	10.00'-10.25'		BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	10.0	
						665	
15	5	60	15.00'-15.50'			660	
						655	
20	6	22-22-34	20.00'-21.17'		BOTTOM OF BORING @ 21.5	21.5	
						655	
25						650	
						645	
30							
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-9

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 676.0	HOLE NO. B-10
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 6.5 FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	1-2-2-3	0.00'-2.00'		TOPSOIL		
					LIGHT BR.FINE-MED.SAND, LITTLE SILT	0.75	
	2	7-10-10-13	2.00'-4.00'				
					GREY/BR.FINE-MED.SAND, LITTLE SILT	3.0	
5	3	12-18-19-13	4.00'-6.00'				
					GREY FINE-CRS.SAND, LITTLE SILT, TRACE GRAVEL	5.5	
						670	
10	4	9-12-14	10.00'-11.50'		GREY FINE-CRS.SAND, SOME SILT, LITTLE GRAVEL, FEW COBBLES	10.0	
						665	
15	5	22-32-29	15.00'-16.50'				
						660	
20	6	51-60	20.00'-20.58'				
					BOTTOM OF BORING @ 20.6'	20.6	
						655	
25							
						650	
30							
						645	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-10

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 683.0	HOLE NO. B-11
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 4.0 FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	1-1-5-3	0.00'-2.00'		TOPSOIL BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL & ROOTS	0.56	
	2	7-33-60	2.00'-3.33'		LIGHT BR.FINE-CRS.SAND, SOME GRAVEL, TRACE SILT	2.0	
5	3	10-16-20	4.00'-5.50'		GREY/BR.FINE-CRS.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	3.0	
						680	
						675	
10	4	5-12-16	10.00'-11.50'				
						670	
15	5	16-36-60	15.00'-16.42'				
						665	
20	6	45-60	20.00'-21.00'				
						660	
					WEATHERED ROCK	22.0	
					BOTTOM OF BORING @ 22.5' (AUGER REFUSAL)	22.5	
25							
						655	
30							
						650	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-11

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 693.0	HOLE NO. B-12
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 4.7 FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	1-1-1-1	0.00'-2.00'		TOPSOIL	0.50	
					BR.SILT AND FINE-MED.SAND	1.5	
	2	11-23-29-60	2.00'-3.83'		BR.FINE-MED.SAND, SOME SILT, LITTLE GRAVEL, FEW COBBLES	690	
5	3	21-23-25-23	5.00'-7.00'		GREY/BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL	5.0	
						685	
10	4	17-26-32	10.00'-11.50'			680	
15					BOTTOM OF BORING @ 14.0' (AUGER REFUSAL)	14.0	
						675	
20						670	
						665	
25						660	
30							
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-12

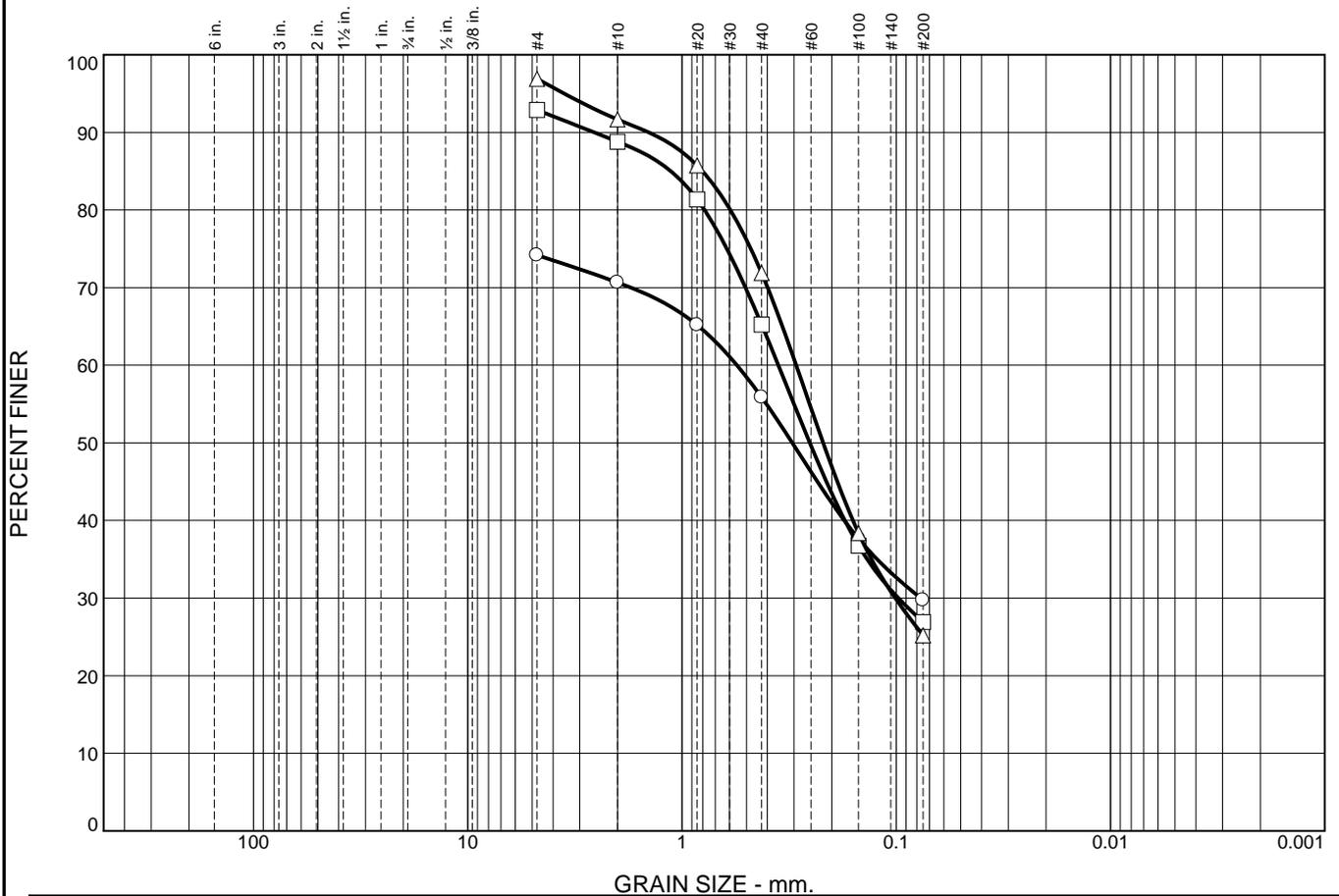
CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 674.5	HOLE NO. B-13
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 7.0 FT. AFTER 0 HOURS	START DATE 12/26/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/26/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	2-3-6-6	0.00'-2.00'		TOPSOIL BR.FINE-CRS.SAND, LITTLE GRAVEL, TRACE SILT	0.50	
	2	13-12-14-28	2.00'-3.83'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL	2.0	
5	3	22-29-40-44	5.00'-7.00'			670	
10	4	3-4-7	10.00'-11.50'			665	
15	5	14-21-36	15.00'-16.50'			660	
20	6	27-57-47	20.00'-21.50'		GREY/BR. FINE-CRS.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	20.5	
25	7	37-60	25.00'-25.58'		BOTTOM OF BORING @ 25.6'	25.6	
30						645	
35						640	
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-13

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 689.0	HOLE NO. B-14
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT 8.0 FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0	1	5-6-7-9	0.00'-2.00'		TOPSOIL	0.33	
					LIGHT BR.FINE-MED.SAND, LITTLE SILT, TRACE ASPHALT - FILL	1.5	
	2	11-60	2.00'-3.00'		GREY FINE-CRS.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES		
						685	
5	3	8-12-14	5.00'-6.50'		GREY FINE-MED.SAND, SOME SILT, LITTLE GRAVEL	5.0	
						680	
10	4	60	10.00'-10.00'		GREY/BR. FINE-MED.SAND, SOME SILT, LITTLE GRAVEL, FEW COBBLES & BOULDERS	10.0	
						675	
15	5	25-60	15.00'-15.92'				
						670	
20	6	18-23-60	20.00'-21.42'				
						665	
25							
						660	
30							
						655	
35							
					BOTTOM OF BORING @ 21.4'	21.4	
						665	
						660	
						655	
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: T. CZMYR INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-14

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
				TOWN OF ELLINGTON		LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV. 685.8	HOLE NO. B-15
TYPE	HSA		SS		LINE & STA.	GROUND WATER OBSERVATIONS	
SIZE I.D.	3.75"		1.375"		N. COORDINATE	AT none FT. AFTER 0 HOURS	START DATE 12/28/12
HAMMER WT.			140lbs		E. COORDINATE	AT FT. AFTER HOURS	FINISH DATE 12/28/12
HAMMER FALL			30"				
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0					ASPHALT	0.17	
	1	6-10-12-15	1.00'-3.00'		BR.FINE-CRS.SAND, LITTLE SILT & GRAVEL	685	
	2	20-17-20-21	2.00'-4.00'		GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL, FEW COBBLES	2.0	
5	3	30-30-60	5.00'-6.50'			680	
10	4	28-30-42	10.00'-11.50'			675	
15	5	60	15.00'-15.50'			670	
20	6	60	20.00'-20.33'		BOTTOM OF BORING @ 20.4'	20.4	
25						660	
30						655	
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: K.CHRISTIANA INSPECTOR:	
						SHEET 1 OF 1	HOLE NO. B-15

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033				CLIENT TOWN OF ELLINGTON		PROJECT NAME ADDITION TO CRYSTAL LAKE SCHOOL	
						LOCATION 284 SANDY BEACH ROAD, ELLINGTON, CT	
	AUGER	CASING	SAMPLER	CORE BAR.	OFFSET	SURFACE ELEV.	HOLE NO. TP-2
TYPE					LINE & STA.	GROUND WATER OBSERVATIONS AT none FT. AFTER 0 HOURS	START DATE 12/26/12
SIZE I.D.					N. COORDINATE		AT FT. AFTER HOURS
HAMMER WT.					E. COORDINATE		
HAMMER FALL							
DEPTH	SAMPLE			A	STRATUM DESCRIPTION + REMARKS	ELEV.	
	NO.	BLOWS/6"	DEPTH				
0					TOPSOIL		
					BR.FINE SAND AND SILT, TRACE ROOTS	2.0	
					GREY/BR.FINE-CRS.SAND, LITTLE SILT & GRAVEL	3.5	
5					GREY FINE-MED.SAND, SOME SILT, TRACE GRAVEL	5.0	
					BOTTOM OF TEST PIT @ 8.0'	8.0	
10					NOTE: SOILS WERE SATURATED BELOW 6 FEET		
15							
20							
25							
30							
35							
LEGEND: COL. A: SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%						DRILLER: INSPECTOR: M. WELTI	
						SHEET 1 OF 1	HOLE NO. TP-2

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines			
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay		
○			3.5	14.8	26.2	29.7			
□			4.1	23.6	38.3	26.9			
△			5.2	19.8	46.7	25.2			
LL	PL	D85	D60	D50	D30	D15	D10	Cc	Cu
○			0.5543	0.3057	0.0770				
□		1.1272	0.3551	0.2533	0.0977				
△		0.8027	0.2933	0.2195	0.1011				

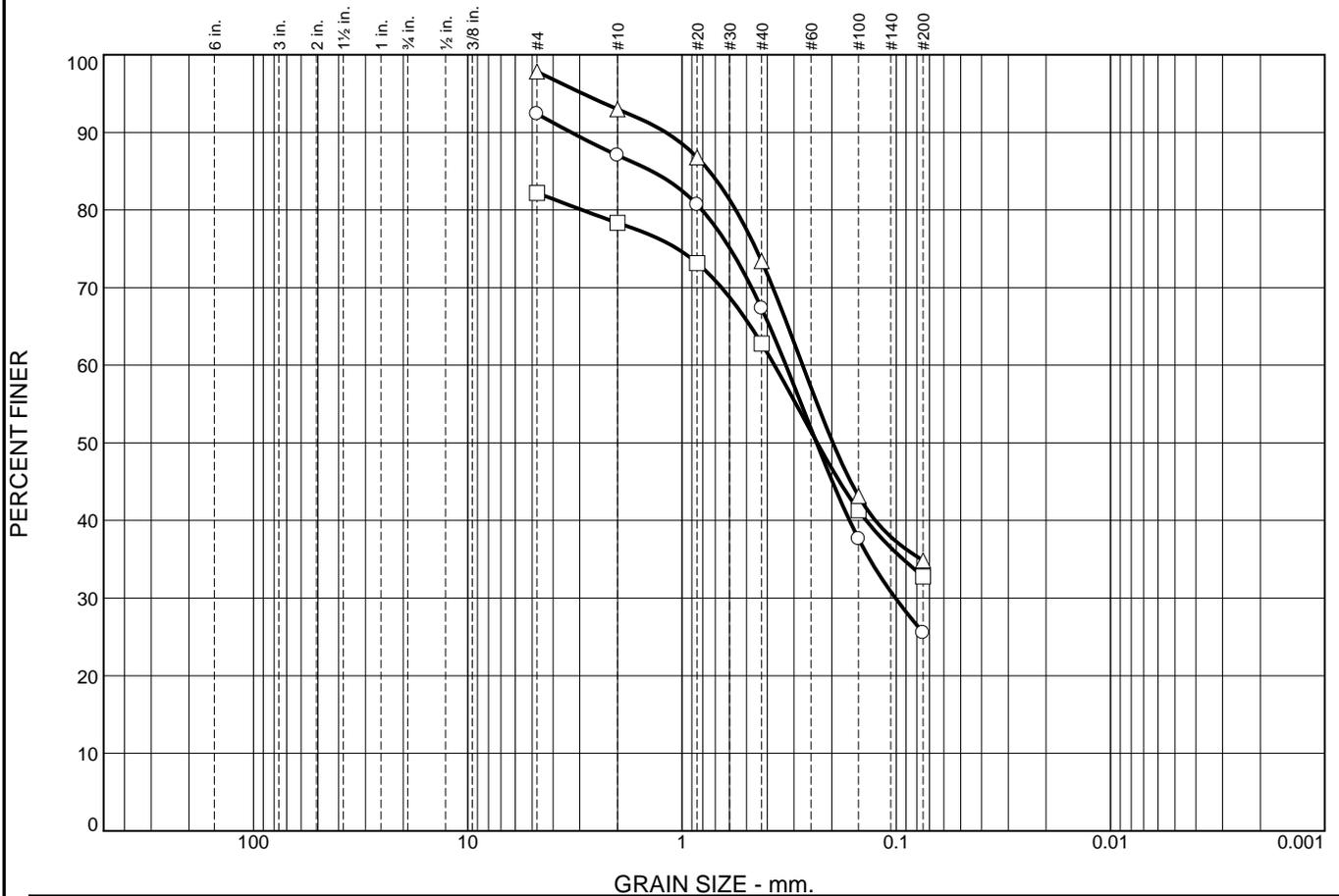
Material Description	USCS	AASHTO
○ BR.FINE-MED.SAND, SOME SILT, TRACE GRAVEL		
□		
△		

Project No.	Client: TOWN OF ELLINGTON	Remarks: ○ water content = 11.1% □ water content = 15.8% △ water content = 8.3%
Project: ADDITION TO CRYSTAL LAKE SCHOOL		
○ Source of Sample: B-2 Depth: 0.56		
□ Source of Sample: B-3 Depth: 2.0 Sample Number: 2		
△ Source of Sample: B-4 Depth: 4.0 Sample Number: 3		

CLARENCE WELTI ASSOCIATES, INC.

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines			
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay		
○			5.4	19.7	41.8	25.5			
□			3.9	15.5	30.0	32.8			
△			4.8	19.6	38.6	34.8			
LL	PL	D85	D60	D50	D30	D15	D10	Cc	Cu
○		1.3835	0.3275	0.2355	0.1009				
□			0.3703	0.2340					
△		0.7451	0.2737	0.1977					

Material Description						USCS	AASHTO	
○								
□								
△								

Project No. _____ **Client:** TOWN OF ELLINGTON
Project: ADDITION TO CRYSTAL LAKE SCHOOL

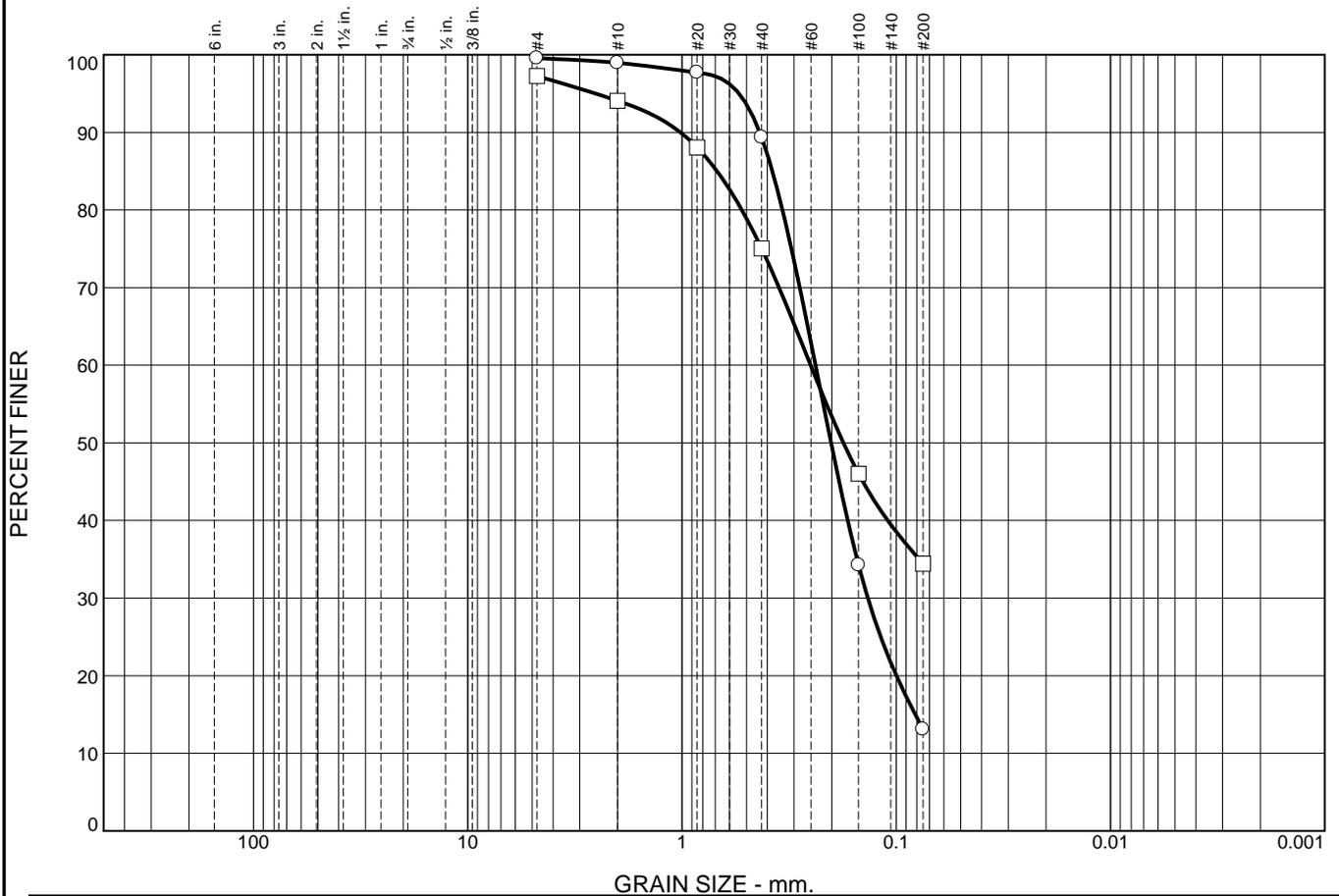
○ **Source of Sample:** B-6 **Depth:** 4.0 **Sample Number:** 3
 □ **Source of Sample:** B-7 **Depth:** 2.0 **Sample Number:** 2
 △ **Source of Sample:** B-9 **Depth:** 2.0 **Sample Number:** 2

Remarks:
 ○ water content = 10.4%
 □ water content = 9.4%
 △ water content = 15.6%

CLARENCE WELTI ASSOCIATES, INC.

Figure

Particle Size Distribution Report



% +3"		% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
<input type="radio"/>				0.6	9.6	76.3	13.1	
<input type="checkbox"/>				3.2	19.1	40.6	34.4	

LL	PL	D85	D60	D50	D30	D15	D10	Cc	Cu
<input type="radio"/>		0.3787	0.2383	0.2016	0.1358	0.0815			
<input type="checkbox"/>		0.6864	0.2511	0.1766					

Material Description						USCS	AASHTO	
<input type="radio"/>								
<input type="checkbox"/>								

Project No. _____ **Client:** TOWN OF ELLINGTON
Project: ADDITION TO CRYSTAL LAKE SCHOOL

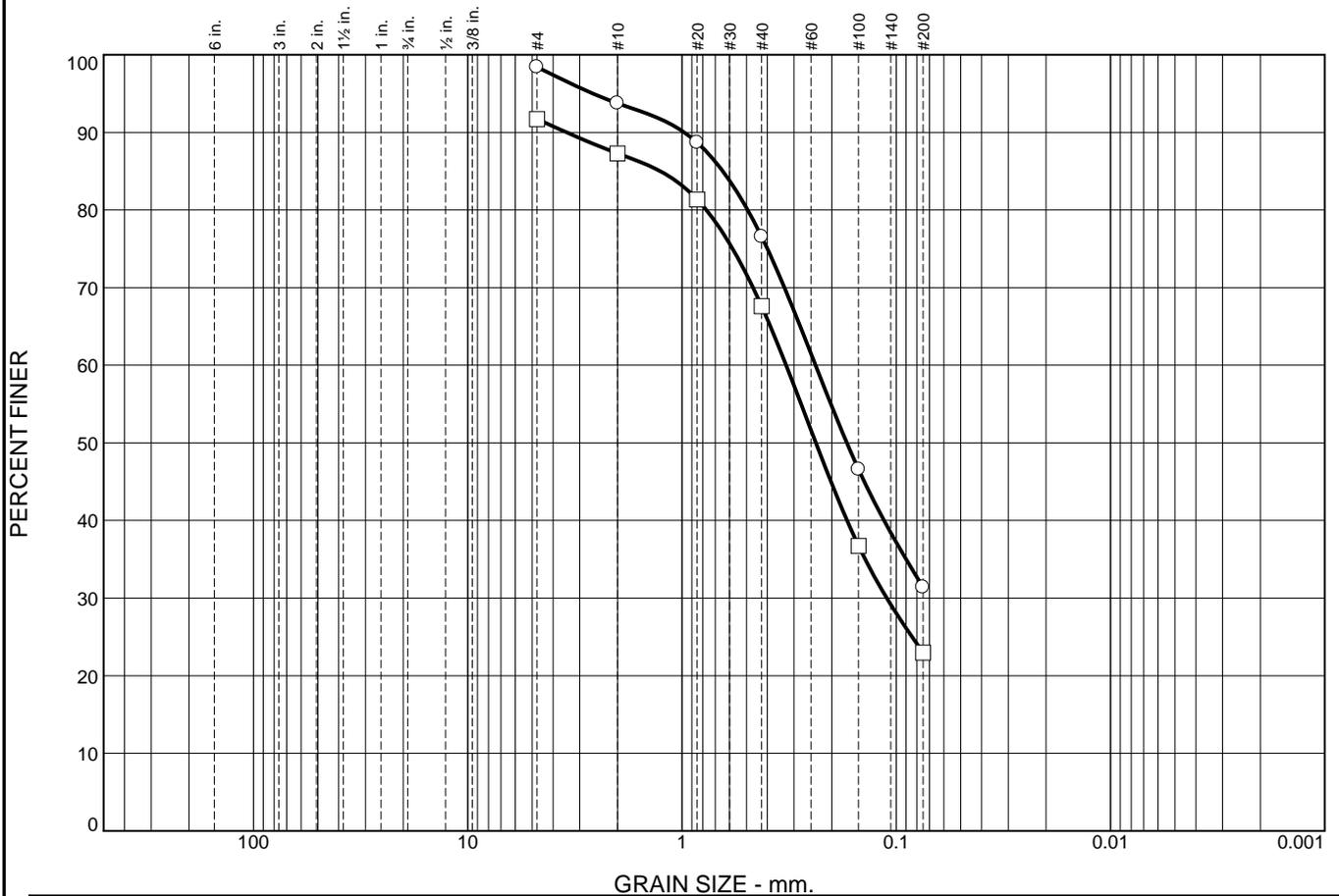
Source of Sample: B-10 **Depth:** 2.0 **Sample Number:** 2
 Source of Sample: B-12 **Depth:** 2.0 **Sample Number:** 2

Remarks:
 water content = 9.8%
 water content = 9.8%

CLARENCE WELTI ASSOCIATES, INC.

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○				4.7	17.1	45.2	31.4	
□				4.4	19.7	44.6	23.0	

	LL	PL	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
	○			0.6450	0.2382	0.1701				
□			1.2638	0.3267	0.2373	0.1107				

Material Description	USCS	AASHTO

Project No. Project: ADDITION TO CRYSTAL LAKE SCHOOL	Client: TOWN OF ELLINGTON	Remarks: <input type="radio"/> water content = 11.8% <input type="checkbox"/> water content = 8.5%
<input type="radio"/> Source of Sample: B-14 Depth: 2.0 Sample Number: 2 <input type="checkbox"/> Source of Sample: B-15 Depth: 1.0 Sample Number: 1		

CLARENCE WELTI ASSOCIATES, INC.

Figure

SECTION 31 2319 - DEWATERING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removal of surface water and ground water as necessary to perform the construction required by the contract.
2. Constructing, installing, building, and maintaining all necessary temporary water extraction and management facilities.
3. Furnishing, installing, and operating all necessary pumps, piping, and other equipment.
4. Complying with all applicable approvals, authorizations or permits associated with the management of dewatering wastewaters.
5. Removing all such temporary works and equipment after their intended function is no longer required.

B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

C. Contractor is responsible for all health and safety.

1.2 REFERENCES

A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.

B. Code of Federal Regulations (CFR)

1. 29 CFR 1926, Safety and Health Regulations for Construction.

C. Connecticut Department of Energy and Environmental Protection (DEEP)

1. Connecticut Guidelines for Soil Erosion and Sediment Control, DEP Bulletin 34, State of Connecticut Council on Soil and Water Conservation, 2002.
2. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities, (DEP-PED-GP-015), latest issue.
3. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Groundwater Remediation Wastewater to a Sanitary Sewer (DEP-PERD-GP-007), latest issue.
4. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Groundwater Remediation Wastewater Directly to Surface Water (DEP-PED-GP-020), latest issue.

-
- D. Regulations of Connecticut State Agencies (RCSA)
 - 1. RCSA Section 22a-372-1, 22a-377(b)-1, 22a-377(c)-1, 22a-377(c)-2, Water Diversion.
 - 2. RCSA Section 22a-430-3 through 4, General Conditions Applicable to Water Discharge Permits and Procedures and Criteria for Issuing Water Discharge Permits.
 - 3. RCSA Section 22a-430-8, Underground Injection Control.

1.3 DESCRIPTION OF THE WORK

- A. Prevent surface water and subsurface or groundwater from flowing into excavations or earthwork areas which would cause flooding of the Project Site and surrounding area, or softening or loosening of the soil at excavation or earthwork subgrade.
- B. Provide adequate and satisfactory dewatering and drainage of excavations and furnish all materials and equipment and do all incidental work required in conjunction with the furnishing, installing, and maintaining of same to permit proper and timely completion of all work required.
- C. Contractor may choose any satisfactory dewatering method he wishes subject to the approval of Engineer, provided such method performs the dewatering required and complies with applicable approvals, authorizations and permits.
- D. Contractor shall assume all responsibility for the adequacy of the methods, materials, and equipment employed. Contractor shall take all precautions necessary to prevent loosening or softening of the subgrade. In this regard, Contractor shall at all times be prepared to alter his construction method or sequence.
- E. The work shall be maintained dry until the structures (building slabs and footings, paved area, pipe, drainage structure, embankments, etc.) are completed.
- F. All dewatering required by pumping and drainage shall be performed without damage to the excavation, pipe trench, pavements, pipes, electrical conduits, other utilities and any other work or property. Existing or new sanitary sewers shall not be used to dispose of drainage.

1.4 SUBMITTALS

- A. Dewatering Plan: Prior to installation of the dewatering system, submit design data showing the following, for review by Engineer:
 - 1. Locations and associated construction where dewatering is required.
 - 2. Specific methods and devices proposed for dewatering.
 - 3. Details on protection at the inlet and outlet of pumps, method for floating the pump intake, or other methods to minimize and retain the sediment.
 - 4. Proposed location of dewatering discharge and details of infiltration basins or other discharge location. Per the General Permit, where feasible and appropriate, dewatering wastewaters will be infiltrated into the ground.
 - 5. Details on any containment berm construction when dewatering earth materials.

6. Identification of a contingency plan for emergency operations should the dewatering operation prove inadequate to meet the dewatering need or is found to be causing unacceptable turbidity problems (e.g., alternative discharge locations or use of a portable sediment tank). If turbidity or siltation problems are not adequately controlled by the contingency plan, then the operation will be ceased and a revised dewatering plan submitted for approval prior to further implementation.

1.5 REGULATORY COMPLIANCE

A. Comply at all times with the following as applicable to the Project:

1. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities, (DEP-PED-GP-015), latest revision. Conditions of such permit, other conditions of approval or authorizations, and any Stormwater Pollution Prevention Plans shall become part of the Contract Documents.
2. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Groundwater Remediation Wastewater to a Sanitary Sewer (DEP-PERD-GP-007), latest revision. The conditions of such permit, other conditions of approval or authorizations, and any supplemental plans shall become part of the Contract Documents.
3. Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Groundwater Remediation Wastewater Directly to Surface Water (DEP-PED-GP-020), latest revision. The conditions of such permit, other conditions of approval or authorizations, and any supplemental plans shall become part of the Contract Documents.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 JOB CONDITIONS

- A. Surface Drainage: Intercept and divert precipitation, and surface water, away from excavations through the use of temporary diversion swales, temporary sediment traps, pipes, sumps or other approved means.
- B. Drainage of Excavated Areas: Provide and maintain ditches of adequate size to collect surface and seepage water, which may enter the excavations. Divert the water into sumps and storm drains or pump into drainage channels or storm drains. When water is to be diverted into a storm drain, provide dewatering settling basins, or other accepted apparatus, such as fractionation tanks, as required to reduce the amount of fine particles, which may be carried into the drain. If a storm drain becomes blocked due to dewatering operation, it shall be cleaned by the Contractor at his own expense.

3.2 DEWATERING

- A. Where feasible and appropriate, dewatering wastewaters will be infiltrated into the ground. Dewatering wastewaters discharged to surface waters will be discharged in a manner that minimizes the discoloration of the receiving waters. The following measures will be

employed to ensure that dewatering wastewaters will not cause scouring or erosion or contain suspended solids in amounts that could reasonably be expected to cause pollution:

- B. Divert surface waters away from areas needing dewatering.
- C. Consider if well points and sumps can be used to lower the groundwater table reducing the need for settling facilities.
- D. For sites that don't require continuous pumping, pump work areas before construction activities begin each work day.
- E. Provide filtration near the suction intake.
- F. Locate pumps, intake sumps, and other intake structures in areas which will not require constant moving, when possible.
- G. Locate pump discharge facilities (portable, permanent, or bio-filtering structures) such that a minimum disturbance of existing wetlands and watercourses is incurred.
- H. Provide protection at outlets from pumping operations to dissipate pumping surges and prevent erosion at the point of discharge.
- I. Maintain the water level at such lowered elevations that no danger to structures can occur because of the buildup of excessive hydrostatic pressure on the subgrade, or bottom of trench, unless otherwise permitted by Engineer.
- J. Do not allow water to accumulate in excavations. At all times during construction, provide ample means and devices with which to remove promptly and dispose properly of all water entering roadway, trench, and structure excavations and keep them dry until the structures to be built thereon are completed.
- K. No pipe/culvert/structure shall be laid in water. No masonry shall be laid in water, and no water shall be allowed to rise over masonry (either concrete or brick) in 24 hours after being placed. Nor shall moving water be allowed to rise over masonry for four days. In no event shall water be allowed to rise so as to set up unequal pressures in the structures until the concrete or mortar has set at least 24 hours. The Contractor shall constantly guard against the possibility of flotation of pipe or structures after installation. He shall place adequate backfill promptly in accordance with Section 31 2310 - Earthwork to prevent this occurrence, and his method of handling drainage and carrying on these operations shall always be adequate to prevent flotation.

END OF SECTION

SECTION 31 2543 – GEOTEXTILE LAYER SEPARATION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Furnishing and installation geotextile materials for the separation of earth materials.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.
- C. Contractor is responsible for all health and safety.

1.2 REFERENCES

- A. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- B. American Society for Testing and Materials (ASTM)
 - 1. ASTM D3786-06e1 - Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method.
 - 2. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
 - 3. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - 4. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 5. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - 6. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - 7. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
- C. Code of Federal Regulations (CFR)
 - 1. 29 CFR Part 1926 Subpart P - OSHA Excavation Regulations 1926.560 through 1926.562 including Appendices A through F.

1.3 QUALITY CONTROL

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section.

1.4 SUBMITTALS

- A. Submit to Engineer for approval material specifications, manufacturer’s product data, and shop drawings for all materials furnished under this Section.
- B. Connection details for geotextile.
- C. Proposed mechanical connection devices.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Follow geotextile manufacturer’s recommendations for packaging, transportation, and delivery to ensure materials are not damaged. Furnish the geotextile fabric in a wrapping that protects the fabric from ultraviolet radiation and from abrasion due to shipping and hauling.
- B. Geotextile shall be stored on a prepared surface (not wooden pallets) and should not be stacked more than two rolls high. Storage shall be such that the geotextile is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or cold, or other damaging circumstances. Temporary storage at the Project Site shall be away from standing water such that crushing or flattening of roll goods does not occur.

PART 2 PRODUCTS

2.1 FILTRATION GEOTEXTILE

- A. Filtration Geotextile shall be utilized for subsurface drainage.
 - 1. Composition: Nonwoven, polypropylene staple fibers.
 - 2. Physical properties:

Mechanical and Physical Properties of Filtration Geotextile

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength, Ultimate	ASTM D 4632	Pounds	110
Grab Tensile Strength, Elongation at Ultimate	ASTM D 4632	Percent (%)	50
Trapezoid Tear Strength	ASTM D 4533	Pounds	50
Mullen Burst Strength	ASTM D 3786	psi	225
Puncture Strength	ASTM D 4833	Pounds	60
Apparent Opening Size (AOS)	ASTM D 4751	(U.S. Sieve)	70
Permittivity	ASTM D 4491	sec ⁻¹	1.7
Flow Rate	ASTM D 4491	gal/min/ft ²	135
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70
Physical Properties	Test Method	Unit	Average Roll

			Value
Weight	ASTM D 3776	oz/yd ²	4.0
Thickness	ASTM D 5199	Mils (mm)	44 (1.12)

2.2 SEPARATION GEOTEXTILE

- A. Separation Geotextile shall be utilized to separate layers of earth materials.
1. Composition: Woven geotextile made of 100% polypropylene slit film yarns.
 2. Physical properties:

Mechanical and Physical Properties of Separation Geotextile

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength, Ultimate	ASTM D 4632	Pounds	250
Grab Tensile Strength, Elongation at Ultimate	ASTM D 4632	Percent (%)	15
Trapezoid Tear Strength	ASTM D 4533	Pounds	90
Mullen Burst Strength	ASTM D 3786	psi	450
Puncture Strength	ASTM D 4833	Pounds	100
Apparent Opening Size (AOS)	ASTM D 4751	(U.S. Sieve)	40
Permittivity	ASTM D 4491	sec ⁻¹	0.05
Flow Rate	ASTM D 4491	gal/min/ft ²	4
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70

2.3 LIGHT-DUTY STABILIZATION GEOTEXTILE

- A. Light-Duty Stabilization Geotextile shall be utilized under temporary sidewalks and unit pavers when called-for.
1. Composition: Woven geotextile made of 100% polypropylene slit film yarns.
 2. Physical properties:

Mechanical and Physical Properties of Light-Duty Stabilization Geotextile

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength, Ultimate	ASTM D 4632	Pounds	200
Grab Tensile Strength, Elongation at Ultimate	ASTM D 4632	Percent (%)	15
Trapezoid Tear	ASTM D 4533	Pounds	75

Strength			
Mullen Burst Strength	ASTM D 3786	psi	400
CBR Puncture Strength	ASTM D 6241	Pounds	90
Apparent Opening Size (AOS)	ASTM D 4751	(U.S. Sieve)	50
Permittivity	ASTM D 4491	sec ⁻¹	0.05
Flow Rate	ASTM D 4491	gal/min/ft ²	5
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70

2.4 STABILIZATION GEOTEXTILE

A. Stabilization Geotextile shall be utilized for stabilization of subgrades where unsuitable subsurface soil conditions are present. Stabilization geotextile shall only be utilized with the approval of Engineer.

1. Composition: Woven geotextile made of 100% polypropylene slit film yarns.
2. Physical properties:

Mechanical and Physical Properties of Stabilization Geotextile

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength, Ultimate	ASTM D 4632	Pounds	315
Grab Tensile Strength, Elongation at Ultimate	ASTM D 4632	Percent (%) MD/TD	12/12
Trapezoid Tear Strength	ASTM D 4533	Pounds	120
CBR Puncture Strength	ASTM D 4833	Pounds	900
Apparent Opening Size (AOS)	ASTM D 4751	(U.S. Sieve)	40
Permittivity	ASTM D 4491	sec ⁻¹	0.05
Flow Rate	ASTM D 4491	gal/min/ft ²	4
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70

MD - Machine Direction
 TD - Transverse (Crosswise) Direction

PART 3 EXECUTION

3.1 GENERAL

A. Placement of a geotextile fabric is required to separate crushed stone from the surrounding soils or layers of varying earthen materials in backfill locations.

- B. Install geotextile as shown on the Drawings or as called-for in the Specifications.
- C. Ensure that geotextile is protected during installation from clogging, tears, and other damage.

3.2 PIPE OR DRAINAGE SYSTEMS

- A. Provide smooth side and bottom trench surfaces so the fabric does not bridge depressions in the soil and is not damaged by rock projections.
- B. Use fabric of a width to permit a minimum trench-width overlap across the backfill at the trench top.
- C. Lay the fabric flat in the prepared trench without stretching. Lay the top of the fabric back on the sides to allow for the placement of the aggregate backfill and pipe.
- D. Overlap ends of rolls an amount equal to the trench width prior to fabric placement. Where pockets or cavities occur in the trench bottom or sides, fill them with acceptable granular material to prevent distortion or damage to the fabric.
- E. Backfill aggregate and install pipe in a manner to prevent damage to the fabric. Compact aggregate backfill and overlap the fabric across the trench top. Do not allow the fabric to be exposed for more than 2 weeks without covering with backfill.

3.3 LAYER SEPARATION AND STABILIZATION

- A. Place fabric on a normally prepared subgrade area attending the full width of the sub-base layer being protected.
- B. Place fabric in a loose and unstretched condition to minimize shifting, puncture, and/or tearing. Overlap fabric roll-ends and edges a minimum of 12 inches with adjacent material.
- C. Place subbase material within 2 weeks after placement of fabric to minimize exposure. Place sub-base material in a manner to minimize slippage of the fabric. If excessive slippage occurs, use steel securing pins per manufacturer's guidelines.

END OF SECTION

SECTION 31 6000 - GABIONS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. Furnishing, assembling, filling and tying open wire mesh rectangular compartmented gabions placed on a prepared surface as specified and in accordance with the lines, grades, and dimensions shown or otherwise established in the field.
2. Gabions are wire mesh containers of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the project site to form flexible, permeable, monolithic structures. Gabions shall be manufactured with all components mechanically connected at the production facility with the exception of the mattress lid, which is produced separately from the base.

B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

C. Contractor shall be responsible for the health and safety of all Contractor and Subcontractor workers during progress of the work.

1.2 REFERENCES

A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.

B. State of Connecticut Department of Transportation (ConnDOT)

1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.

C. Code of Federal Regulations (CFR)

1. 29 CFR 1926, Safety and Health Regulations for Construction.

D. American Society for Testing and Materials (ASTM)

1. ASTM A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A 641 - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
3. ASTM A974 - Standard Specification for Welded Wire Fabric Gabions and Gabion Mattresses (Metallic Coated or Polyvinyl Chloride (PVC) Coated).

1.3 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained, experienced, and as required licensed, in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

1.4 DELIVERY, STORAGE AND HANDLING

- A. All gabions shall be supplied in the collapsed form, either folded or bundled or rolled, for shipping. Bundles are banded together at the factory for ease of shipping and handling.
- B. Deliver, move, store, or otherwise handle equipment to avoid damage to the gabion structure or wire coating.

1.5 SUBMITTALS

- A. Submit to Engineer for approval material specifications and shop drawings for all materials furnished under this Section.
- B. Working drawings detailing the layout of the gabions at least two weeks prior to their installation.

1.6 MOCKUPS

- A. At a project location selected by Engineer, place and finish one gabion basket section mockup section for examination.
- B. Construct mockup using processes and techniques intended for use on permanent work, including curing procedures. Mockup shall be produced by the individual workers who will perform the work for the Project.
- C. Accepted mockup provides visual standard for work of Section.
- D. Mockup shall remain through completion of work for use as a quality standard for finished work.
- E. Remove mockup when directed.

PART 2 PRODUCTS

2.1 WIRE FABRIC GABIONS

- A. Welded Wire Fabric Gabions, ASTM A974. Manufactured with a welded wire mesh composed of a series of longitudinal and transverse steel wires arranged substantially at right angles to each other, and welded together at the points of intersection by electrical resistance welding to form fabricated sheets.
- B. Welded wire fabric made from uncoated wire with fabric subsequently zinc-coated after fabrication. Spiral binders, lacing wire, and stiffeners are produced from zinc-coated wire.
 - 1. Wire mesh: Steel wire, minimum diameter of 0.118 inches. Tensile strength: 60,000 psi minimum. Elongation of 12% minimum. Coated in accordance with ASTM A 641, Finish 5, Class 3.

- a. Mesh configuration: Square. Dimension 3- inches by 3-inches.
- 2. Lacing Wire: Galvanized steel, minimum diameter of 0.087 inches. Tensile strength: 60,000 psi minimum. Elongation of 12% minimum, ASTM A 641.
- 3. Selvedge Wire: Galvanized steel wire with a minimum diameter of 0.148 inches. Selvedge wire shall run through the edges of the basket.

2.2 INFILL STONE

- A. General: Material shall consist of sound, tough, durable rock, free from decomposed stones or other defects impairing its durability.
- B. Size and visual characteristics: As indicated on the Drawings.

2.3 PERVIOUS STRUCTURE BACKFILL

- A. Broken or crushed stone, gravel, or a mixture thereof.
 - 1. Broken or crushed stone: sound, tough, durable stone, reasonably free from soft, thin, elongated, friable, laminated, micaceous or disintegrated pieces, mud, dirt or other deleterious material.
 - 2. Bank or crushed gravel: sound tough, durable particles of crushed or uncrushed gravel free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances.
- B. Pervious Structure Backfill shall be graded as follows:

Gradation of Pervious Structure Backfill (ConnDOT Grading “B”)

Sieve	Percent Passing by Weight
5”	100
3 1/2”	90-100
1 1/2”	55-95
1/4 ”	25-60
No. 10	15-45
No. 40	5-25
No. 100	0-10
No. 200	0-5

PART 3 EXECUTION

3.1 PREPARATION

- A. Take precautions for preventing injuries to persons or damage to property in or about the work. Protect structures, utilities, sidewalks, pavements and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

3.2 DIMENSIONS

- A. Baskets shall be constructed to conform to the details shown on the plans, or as directed by the Engineer. All baskets shall be of uniform width. All basket units shall be subdivided into equal compartments and separated by diaphragms of the same mesh and wire diameter as the basket body. Each compartment's length shall not exceed its width. The overall height of the gabion shall not exceed its overall width.

3.3 FABRICATION

- A. The baskets shall be fabricated so that the sides, ends, lids and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. The wire mesh shall be cut so as to be non-raveling. The front, base, back and lid shall be woven into a single unit. The ends shall be factory-connected to the base section of the basket so that strength and flexibility at the point of connection are at least equal to that of the mesh. All perimeter edges of the mesh shall be securely fastened with selvedge wire so that the joints have at least the same strength as the wire mesh. Lacing wire shall be supplied in a quantity sufficient for securely fastening all edges of the baskets and diaphragms and to provide for the necessary internal connecting wires in each compartment. There shall be 4 cross connecting wires in each compartment whose height is either 1/3 or 1/2 the width of the gabion and 8 cross connecting wires in each compartment whose height equals the width of the gabion. Each basket unit shall be assembled by binding together all vertical edges with lacing wire at intervals of no more than 5 inch (125 millimeters) spacing or by a continuous piece of lacing wire looped around the vertical edges with at least one tie every 5 inches.
- B. Empty baskets shall be set to line and grade as shown on the Drawings. All adjoining empty basket units must be laced along the perimeter of their contact surfaces in the manner described previously for assembling. The empty upper baskets that form the upper tier shall also be laced to the top of the lower ones. A standard fence-stretcher or other approved device shall be used to remove any kinks from the mesh and hold alignment of the units. The aggregate shall be carefully placed to ensure alignment, avoid bulges and create a minimum of voids. After the aggregate is placed to the level at which the connecting wires are to be installed, two connecting wires are to be placed perpendicular to each other, then looped and tied around 2 meshes of each gabion wall. Filling is then resumed until the level of the next connecting wires or the top of the gabion is reached. After a gabion has been filled, the lid shall be stretched tightly over the filling until the lid meets the perimeter edges of the front and end panels. The lid shall then be tightly laced along all edges, ends and diaphragms in the manner described for assembling.

3.4 CLEAN-UP

- A. Contactor shall clean up debris resulting from gabion installation continuously with the progress of the work.

END OF SECTION

SECTION 31 37 00 - RIP RAP

PART 1 GENERAL

1.1 SUMMARY

- A. This Section defines requirements for the procurement and placement of rip rap.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.
- C. Rip rap shall be used to used to protect foundations of piers, abutments, walls, slopes of embankments and waterways from water damage.

PART 2 PRODUCTS

- A. Rip Rap: Material shall consist of sound, tough, durable and angular rock, free from decomposed stones or other defects impairing its durability. The size of a stone as hereinafter specified shall be its least dimension. Broken concrete or rounded stones are not acceptable. The type of material to be used shall be as noted on the plans, in the special provisions or as may be ordered by the Engineer.
 - 1. Standard Rip Rap: Material shall conform to the following requirements.
 - a. Not more than 15% of the rip rap shall be scattered spalls and stones less than 6 inches in size
 - b. No stone shall be larger than 30 inches in size, and at least 75% of the weight (mass) shall be stones at least 15 inches in size.
 - 2. Intermediate Rip Rap: This material shall conform to the following gradation:

Gradation of Intermediate Rip Rap

Stone Size	% of the weight (mass)
18 inches	0
10 inches to 18 inches	30-50
6 inches to 10 inches	30-50
4 inches to 6 inches	20-30
2 inches to 4 inches	10-20
Less than 2 inches	0-10

3. Modified Rip Rap: This material shall conform to the following gradation:

Gradation of Modified Rip Rap

Stone Size	% of the weight (mass)
10 inches	0
6 inches to 10 inches	20-50
4 inches to 6 inches	30-60
2 inches to 4 inches	30-40
1 inches to 2 inches	10-20
Less than 1 inches	0-10

4. Special Rip Rap: This material shall conform to the following gradation:

Gradation of Special Rip rap (ConnDOT Gradation No. 3)

Sieve	Percent Passing by Weight
2 1/2"	100
2"	90-100
1 1/2"	35-70
1"	0-15
1/2"	0-5

- B. Bedding: The bedding material for rip rap shall conform to the specifications of the material indicated on the Drawings.

PART 3 EXECUTION

3.1 GENERAL

- A. The area to be protected by rip rap shall be accurately shaped prior to placing of any bedding material or rip rap. Where bedding material is called for, it shall be placed on the prepared area and compacted to the depth, lines and grades indicated on the Drawings.
- B. Rip rap shall be placed to its full course thickness in one operation in such a manner as to produce a reasonably well-graded mass of rock without causing displacement of the underlying material.
- C. The finished surface shall be free from pockets of small stones and clusters of larger stones. Placing this material by methods likely to cause segregation of the various sizes of stone will not be permitted.

- D. Rearranging of individual stones by mechanical or hand methods will be required to the extent necessary to obtain a reasonably well-graded distribution of the specified stone sizes.
- E. The completed course shall be of the specified thickness and to the lines and grades as shown on the plans or as ordered by Engineer.

END OF SECTION

SECTION 314143 -SHEETING AND STAYBRACING

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes
 - 1. Shoring and bracing necessary to protect existing buildings, existing culvert, streets, walkways, utilities, and other improvements and excavation against loss or ground caving embankments.
 - 2. Maintenance of shoring and bracing.
 - 3. Removal of shoring and racing, as required.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- C. Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.

1.3 DESCRIPTION OF THE WORK

- A. Contractor shall install sheeting or staybracing as necessary in order to comply with the Applicable Safety Code; to accommodate traffic; to permit access to existing utilities; to provide an opening of proper depth and width in which to install the proposed pipes and other underground structures; and to protect his workmen, employees of the Owner and (Insert Name), State and the public, from death or injury from bank failure, earth collapse or earth movement of any nature whatsoever. In general, all trenches and excavations over 5 feet in depth, any other unstable excavations or excavations in unstable material, shall be protected against the hazard of collapse.

1.4 SHEETING/STAYBRACING DESIGN

- A. Contractor shall be entirely and solely responsible for the adequacy and sufficiency of all supports and for all sheeting, bracing, shoring, underpinning, cofferdamming, etc. The Contractor shall assume the entire and sole responsibility for damages on account of injury to persons or damage to adjacent pavements and public and private property (including but not limited to, the Work under construction, existing buildings, facilities, etc.) which injury or damage results directly from said Contractor's failure to install, or to leave in place, adequate and sufficient supports, sheeting, bracing, underpinning, cofferdamming, etc.
- B. Contractor shall submit, in triplicate, a detailed written description of the equipment and sheeting methods he proposes to use to Engineer prior to the installation of any sheeting

and/or shoring. These plans should include, but not be limited to, the type of sheeting or shoring, sizes and dimensions, bracing, spacing, methods of installation and removal, etc.

- C. All sheeting shall be designed and sealed by a Professional Engineer licensed to practice in the State where the Work is being performed. He shall be known as the Contractor's Engineer. Sheeting computations and sketches shall be submitted for Engineer's review.

1.5 SHEETING LEFT-IN-PLACE

- A. Sheeting, shoring or other timbering may be left-in-place at the option of the Contractor when needed to protect other existing facilities or the Work built or to be built under this Contract. However, steel sheeting left-in-place will be paid for only where specifically shown as "Steel Sheeting Left-in-Place" on the Contract Drawings or where ordered by Engineer.
- B. It is expressly understood and agreed that removing or leaving-in-place any sheeting or shoring, etc., as noted above, shall not relieve the Contractor from any responsibility for any loss damage whatever due to omission of, or failure of, the sheeting, etc., failure to leave it in place, or the settling of the backfill, or any movement of the ground or any structure or object adjacent to any trench or excavation made by Contractor. Engineer will not order sheeting left-in-place at the expense of the Owner in order to accommodate the convenience of the Contractor or to save him the cost of its removal.

1.6 OPTIONAL METHOD OF TRENCHING

- A. Contractor may, with the approval of Engineer, lay back slopes in accordance with the provisions of the Applicable Safety Code in order to avoid the necessity of sheeting or limiting the quantity thereof. However, in the case of trenches, the toe of this slope will not be lower than one foot above the top of the pipe to be installed. A level bench of at least two (2) feet in width shall be maintained between the toe of the sloped section and vertical trench excavation for pipes with an outside diameter of six (6) feet or less; for pipes with an outside diameter over six (6) feet, a minimum four (4) foot bench shall be provided. Where sloping is used as a substitute for sheeting or staybracing, or used in combination therewith, it shall be sloped a minimum of one horizontal to one vertical except where instability of the material requires a slope flatter than one to one. If the Contractor elects and is allowed to lay back the slopes, there will be no additional payment made for the extra excavation outside of the normal trench or structure excavation payment limits.

1.7 RESPONSIBILITY OF ENGINEER

- A. There shall be no obligation on the part of Engineer to issue orders for sheeting, staybracing or sheeting left-in-place and/or to pass upon sufficiency and adequacy of sheeting; nor shall the failure on the part of Engineer to give such orders relieve the Contractor from liability for damages occasioned by negligence, or otherwise growing out of the Contractor's failure to either install sufficient and adequate sheeting and/or staybracing or to leave in place in the excavation sufficient and adequate support to prevent the caving in or moving of the ground adjacent to the sides of the excavation during and after the backfilling operation.

PART 2 PRODUCTS

2.1 WOOD STAYBRACING

- A. Wood Staybracing

2.2 STEEL SHEETING

- A. Steel sheeting: continuous and interlocking sheets, ASTM A-328.

2.3 TRENCH BOXES

- A. Trench boxes shall not be used unless requested by the Contractor and authorized by Engineer. If authorized, they shall be used only when the protection of workmen is involved, not for support of existing adjacent utilities, structures, embankments, etc. A trench protected by the use of a trench box shall not be considered a sheeted trench.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Unless expressly authorized by Engineer, sheeting shall be driven ahead of the excavation to avoid loss of material from behind the sheeting. If it is necessary to excavate below the sheeting to facilitate driving, care shall be taken to avoid trimming behind the face along which the sheeting will be driven. Care shall be taken to prevent voids outside of the sheeting.
- B. All sheeting and staybracing shall be securely installed and properly braced in accordance with the Applicable Safety Code. Engineer may direct the Contractor at any time in writing to have sheeting, bracing, etc. in place to be embedded in backfill or concrete for the purpose of preventing subsequent injury to structures and property.
- C. The depth of pilot cuts for trenches/structures shall not exceed five (5) feet in depth at any time. Engineer may reduce the depth of the pilot cut should the soil and subsurface conditions warrant such action. Sheeting must be driven by drop hammer or other methods approved in writing by Engineer below the area of the pilot cut. Driving of sheeting above the pilot cut is subject to the directions of Engineer. Engineer may direct the Contractor to use other types of equipment, and to revise the procedure during the excavation of the pilot cut and the driving of the sheeting should it be found necessary to do so.
- D. Vibratory driving hammers shall not be used unless specifically authorized by Engineer.
- E. Where sheeting is specified to be left-in-place, it shall be wood sheeting unless otherwise specifically noted on the Contract Drawings. Where wooden sheeting cannot be driven due to the nature of the material, then steel sheeting may be driven and removed in lieu of the wooden sheeting providing the following procedures are followed:
 1. Simultaneously with the withdrawal of sheeting and as each layer is compacted in accordance with Section 312310 - Earthwork; or
 2. The trench/area will be backfilled to the surface. If the sheeting is to be withdrawn, backfilling will proceed up to each set of rangers and braces; the rangers and braces will be removed; the backfilling will proceed up to the next set of rangers and braces, etc. up to the top of the excavation. The backfill material shall be compacted to 98% of the maximum dry density as determined by AASHTO T 99, Method C. Alternate sections of sheeting from the left side and right side of the trench/area shall be removed and the cavity remaining there from shall be jetted thoroughly by high-pressure water, starting at the toe of the sheeting and being drawn to the surface. Sand shall be inserted with the jetting process.
 3. Where the bottom of the excavation is not free draining material (some areas of organic material or miscellaneous fill) or where granular backfill is not available or ordered by

Engineer, the jetting shall be very carefully done with a minimum amount of water being expended. In such locations, the Contractor may request the approval of Engineer for other compaction methods in the sheeting cavity.

4. Contractor shall remove the sheeting and/or staybracing from the excavation, except where it is specifically indicated on the Contract Drawings "To be Left- in-Place", or the Contractor may elect to leave in place the sheeting and/or staybracing for his own convenience, or to serve his own interest to protect existing facilities, the Work built or to be built under this Contract, or for the safety of the public, etc., at no cost to the Owner. No sheeting or bracing which is within three feet of the existing or proposed finished grade may be left-in-place without the prior permission of Engineer. This may require the Contractor cut off sheeting at this elevation and at no additional cost to the Owner.
5. Where sheeting, regardless of the type of sheeting used, is left in place, as specified or ordered or at the Contractor's convenience/option, unless otherwise specifically permitted in writing by Engineer, all elements such as rangers, braces, wales, etc. shall be left in place except as specified hereinbefore; and, except such temporary braces required to be removed to make way for the structure/utility. Where it is necessary to remove such temporary braces, the sheeting shall be rebraced, but in no case shall the sheeting be braced against the sides of the structure/utility to be constructed unless approved in writing by the owner of the structure/utility. Where lagging and "soldier" beams are used, the "soldier" beams and all the braces shall also be left in place.
6. Where wood sheeting has been driven below the excavation bottom to provide for a "toe-in", no wood sheeting below the top of pipe or structure shall be removed, but it shall be cut off at this elevation and the remaining sheeting above this line removed as described herein. There will be no payment made for this work, nor for the wood sheeting left-in-place.
7. Sheeting shall be cut away and removed from in front of capped outlets or other braces or inlets set in the pipe for future connections.
8. All sheeting, shoring and bracing removed shall be carefully removed from the excavation in such a manner as not to endanger the completed work or any adjacent pavements, buildings, structures, utilities, property, etc. The sheeting shall be withdrawn to such an extent that it is just above the backfill material being compacted and all voids left or caused by the withdrawal of such sheeting, shall be immediately refilled with approved material and compacted at no additional cost to the Owner.
9. Where the excavation is to be left open during non-working hours, the sheeting shall extend 42 inches above existing grade to protect pedestrian and vehicular traffic from the open excavation.

END OF SECTION

SECTION 320116 – IN-PLACE PAVEMENT RECLAMATION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Furnishing of all labor, materials, tools, testing, and equipment necessary to reclaim the bituminous lot, as specified below, to form an asphaltic stabilized base.
 - 2. Work under this Section shall consist of pulverizing the in-place asphalt pavement and underlying material, spraying liquid calcium chloride on the pulverized mass, mixing and/or blending the material, spreading it, adding water as necessary, shaping and compacting the resultant mixture to lines and grades shown on the plans, ready to accept the bituminous concrete pavement.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.

1.3 SAFETY REQUIREMENTS

- A. Contractor shall provide and maintain barricades, signs, lights, etc., required for the protection of personnel, materials and property. Temporary barricades, etc. shall conform all applicable codes and regulations, and shall be lighted at night with lanterns, flares and reflectorized paint as required for safety. Adapt barricades, signs, lights, etc. to evolving site conditions throughout the progress of the work.
- B. Provide other safety devices as required, including adaptation of such safety devices to changing site conditions, to prevent unauthorized entry to construction areas and open excavations. Provide warning signs and other temporary construction safety devices necessary for proper completion of the work in compliance with applicable safety regulations.

1.4 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

PART 2 PRODUCTS

2.1 GENERAL

A. Reclaimed Base

1. All pulverized material shall pass the 3-inch sieve and shall extend at least ten (10) inches below existing grade.

2.2 EQUIPMENT

- A. Reclamation will be by means of a traveling rotary reclaimer or equivalent machine capable of cutting through the existing asphalt at depths of no less than 10 inches with one pass.
- B. The machine shall be self-propelled and equipped with an adjustable grading blade thus leaving its path generally smooth. Equipment such as road planers or cold milling machines, which are designed to mill or shred the existing bituminous concrete rather than to crush or fracture it, are not considered capable of achieving specification gradation and shall not be used.
- C. Existing bituminous concrete and gravel/aggregate base must be pulverized and mixed so as to form a homogeneous mass of uniformly processed base material, which will bond together when compacted.
- D. At least one vibratory roller shall be used on each reclaimed surface, and shall have a compacting width of not less than 5 feet. Each roller shall have a gross weight of not less than 15 tons.
- E. Maintain equipment in satisfactory operating condition and correct breakdowns in a manner that will not delay or be detrimental to progress of reclaiming operations.

PART 3 EXECUTION

3.1 GENERAL

- A. Existing landscaped areas that are to be bituminous pavement under proposed conditions shall have the top 12 inches of topsoil and existing subgrade removed and new subgrade compacted prior to any in place reclamation. This shall be done in preparation for the placement of reclaimed material.
- B. The existing bituminous pavement shall be pulverized and mixed with the existing base course material to a minimum depth of ten (10) inches below grade.
- C. Pulverization shall blend the asphalt and base material into a homogeneous mass.
- D. Shape the material to provide a base that conforms to the design grades. The site has been designed to generally raise the grade approximately three (3) to four (4) inches, in order to accommodate the reclamation process. Elevations at certain critical areas, such as at handicap areas, concrete sidewalks and existing adjacent pavements are not subject to deviation. Additionally, elevations at existing retaining walls shall in no case be lowered.
 - a. Any reclaimed or unclaimed material that is required to be removed from site will be done at the Contractor's expense.
- E. Initial rolling shall be done immediately following the reclaiming operation. Water shall be applied during the entire operation to ensure optimum moisture at the time of compaction.

- F. Avoid damage to existing manholes, catch basins, valve boxes or other castings which may be located in the pavement surface. Any damage to these structures shall be repaired by the Contractor at the Contractor's expense.
- G. After the material has been thoroughly worked as described above it shall be shaped and graded to the lines and elevations as indicated on the plans or as directed by Engineer.

END OF SECTION

SECTION 32 1216 - BITUMINOUS CONCRETE PAVEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. The work under this section consists of the production and placement of a smooth and dense bituminous concrete mixture with a uniform texture for a completed base course, the surface of an existing pavement or the surface of an existing pavement which has been brought to proper grade and cross section.
- B. Section includes:
 - 1. Asphaltic (Bituminous) concrete paving for street, driveway and parking areas.
 - 2. Installation of bituminous concrete overlays over existing pavement, including surface preparation, truing and leveling pavement, tack coating and all other associated items and operations necessary and required to complete the installation.
 - 3. Adjustment of existing castings to finished grade.
 - 4. Saw cutting existing edge of pavements for the construction of a proper pavement butt.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. State of Connecticut Department of Transportation (ConnDOT).
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- D. American Association of State High and Transportation Officials (AASHTO).
 - 1. AASHTO M-17 - Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
 - 2. AASHTO M 82, Cutback Asphalt (Medium-Curing Type) .
 - 3. AASHTO M-208 - Standard Method of Test for Unconfined Compressive Strength of Cohesive Soil-ASTM Designation D 2166.
 - 4. AASHTO M-320 - Standard Specification for Performance-Graded Asphalt Binder.
 - 5. AASHTO R-26 - Standard Recommended Practice for Certifying Suppliers of Performance-Graded Asphalt Binders.
 - 6. AASHTO R-29 - Standard Practice for Grading or Verifying the Performance Grade of an Asphalt Binder.
 - 7. AASHTO T-27 - Sieve Analysis of Fine and Course Aggregates.

- 8. AASHTO T-84 - Specific Gravity and Absorption of Fine Aggregates.
 - 9. AASHTO T-85 - Specific Gravity and Absorption of Coarse Aggregates.
 - 10. AASHTO T-96 - Standard Method of Test for Resistance to Degradation of small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 11. AASHTO T 104 Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
 - 12. AASHTO T-209 - Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
 - 13. AASHTO T-245 - Standard Method of Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.
- E. MS-2: Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types - The Asphalt Institute (AI).
 - F. Hot Mix Asphalt Paving Handbook 2000 - U.S. Army Corps of Engineers, UN-13 (CE MP-ET)
 - G. M-19: Basic Asphalt Emulsion Manual - The Asphaltic Institute (AI).
- 1.3 American Society for Testing and Materials (ASTM)
- A. ASTM D1188 - Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples.
 - B. ASTM D2726 - Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures.
- 1.4 JOB CONDITIONS
- A. Weather Limitations
 - 1. The bituminous concrete mixture shall not be placed whenever the surface is wet or frozen or when the temperature is outside the limitations stated in Table 1 below unless the contractor has a Cold Weather Paving procedure approved by Engineer. Contractor shall be responsible for submitting the procedure at least one week in advance of any paving operations that may result in placement of the bituminous concrete pavement outside of the temperature limitations stated in the following:

Table 1
Temperature Limitations for Placement of Bituminous Concrete Pavement (ConnDOT 4.06.03 (4))

Lift thickness (Inches)	Minimum Air and Surface Temperature (Degrees F)	
	Final Course	All Other Courses
Less than 1- 1/2 inch	50	50
1-1/2 to 2-1/2 in	40	40
Over 2-1/2 in.	40	32

2. Apply tack coat where indicated on the drawings and when ambient temperature is above 40°F, and when temperature has been above 35°F for 12 hours immediately prior to application. Do not apply when base is wet, contains excess moisture, or during rain.

1.5 SUBMITTALS

- A. Request for approval of all material sources of supply.
- B. Material Safety Data Sheet (MSDS) for each grade of binder.
- C. Design Mix: Before any bituminous concrete paving is constructed, submit actual design mix to Engineer for review and/or approval. Design mix submittal shall follow the format as indicated in the Asphalt Institute Manual MS-2, Marshall Stability Method; and shall include the type/name of the mix, gradation analysis, grade of asphalt cement used, Marshall Stability (lbs.), flow, and effective asphalt content (percent).
- D. Material Certificates: Submit Material Certificate to Engineer, which is signed by material producer and Contractor, certifying that materials comply with, or exceed, the requirements herein.

1.6 COORDINATION

- A. Contractor shall coordinate with all other trades, especially underground Utility Contractors, in order to prevent covering up unfinished or uninspected work and loss of time or labor by improper scheduling. Any rework shall be done at no cost to the Owner.

1.7 SUBGRADE TESTING

- A. Subgrade bearing capacity shall be determined by testing. The minimum CBR (California Bearing Ratio) shall be 10. The Contractor shall perform CBR tests as necessary, but in no case less than one test for each 1,000 square yards of paved area.
- B. Contractor shall remove any subgrade areas not meeting the minimum CBR during subgrade preparation. Areas of subgrade removal shall be filled and compacted with suitable material at no extra cost to Owner.

1.8 EQUIPMENT

- A. Contractor shall have the paving and compaction equipment at the Project site in a sufficient amount of time before operations so that it can be inspected and approved by Engineer. The Contractor shall repair or replace any equipment found worn or defective, either before or during paving, to the satisfaction of Engineer.
- B. Pavers: Each paver shall have a receiving hopper with sufficient capacity to provide for a uniform spreading operation and a distribution system that places the mix uniformly, without segregation. The paver shall be equipped with a vibratory screed system with heaters or burners. The screed system shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture. Pavers with extendible screed units as part of the system shall have auger extensions and tunnel extenders as necessary. The screed unit shall have automatic screed controls for grade and slope unless otherwise approved by the Engineer. The controls shall automatically adjust the screed to compensate for irregularities in the preceding course or existing base. The controls shall maintain the proper transverse slope and be readily adjustable, and shall operate from a fixed or moving reference such as a grade wire or floating beam.

- C. Rollers: All rollers shall be self-propelled and designed for compaction of bituminous concrete.
 - 1. Non-vibratory (static) rollers shall be steel wheel types. These rollers may also be of the type that can be used as vibratory rollers.
 - 2. Pneumatic tire rollers shall be self-propelled and equipped with wide-tread compaction tires capable of exerting an average contact pressure from 60 to 90 pounds per square inch uniformly over the surface, adjusting ballast and tire inflation pressure as required. The Contractor shall furnish evidence regarding tire size; pressure and loading to confirm that the proper contact pressure is being developed and that the loading and contact pressure are uniform for all wheels.
 - 3. Vibratory rollers shall be equipped with indicators that provide the operator with amplitude, frequency and speed settings/readouts to measure the impacts per foot during the compaction process.

PART 2 PRODUCTS

2.1 GENERAL

- A. All sources of materials used for the production of bituminous concrete materials must be approved by Engineer prior to their use. Such materials shall include coarse aggregate, fine aggregate, mineral filler and designated bitumen combined to meet the composition limits by weight (mass) and other requirements stated in Table 2.
- B. An adequate quantity of each size aggregate, mineral filler and bitumen shall be maintained at the bituminous concrete plant site at all times while the plant is in operation to ensure that the plant can consistently produce bituminous concrete materials that meet the job mix formula (JMF) as specified in Article 2.5. The quantity of such material shall be approved by Engineer on an individual plant basis and is dependent upon the plant's daily production capacity, but shall never be less than one day's production capacity.

2.2 MINERAL AGGREGATE

- A. Coarse Aggregate
 - 1. Coarse aggregate shall consist of clean, hard, tough, durable fragments of crushed stone or crushed gravel of uniform quality. Aggregates from multiple sources of supply shall not be mixed or stored in the same stockpile.
 - 2. Basis of Acceptance: The request for approval of the source of supply shall include a washed sieve analysis in accordance with AASHTO T-27. The apparent specific gravity (Gsa), bulk specific gravity (Gsb) and percent absorption (Paw) shall be determined in accordance with AASHTO T-85. The aggregate shall not contain more than 1% crusher dust, sand, soft disintegrated pieces, mud, dirt, organic and other injurious materials. When tested for abrasion using AASHTO T-96, the aggregate loss shall not exceed 40.0%. When tested for soundness using AASHTO T-104 with a magnesium sulfate solution, the coarse aggregate shall not have a loss exceeding 10.0% at the end of 5 cycles.
- B. Fine Aggregate
 - 1. Fine aggregate shall consist of clean, hard, tough, rough-surfaced and angular grains, of natural sand; manufactured sand prepared from washed stone screenings; stone

screenings, slag or gravel; or combinations thereof. Fine aggregates from multiple sources of supply shall not be mixed or stored in the same stockpile.

2. Basis of Acceptance: The request for approval of the source of supply must include the location, manufacturing and processing methods. The request for approval shall also include a washed sieve analysis in accordance with AASHTO T-27. Any fine aggregate component or final combined product shall have 100% passing the 3/8 inch (9.5 millimeter) sieve. The apparent specific gravity (G_{sa}), bulk specific gravity (G_{sb}) and percent absorption (P_{aw}) shall be determined in accordance with AASHTO T-84. The fine aggregates shall be free from injurious amounts of clay, loam, and other deleterious substances.

- C. The use of reclaimed asphalt pavement in new bituminous pavement is not permitted.

2.3 MINERAL FILLER

- A. Mineral filler shall consist of finely divided mineral matter such as rock dust, including limestone dust, slag dust, hydrated lime, hydraulic cement, or other approved mineral matter. At the time of use it shall be freely flowing and devoid of agglomerations.
- B. Basis of Acceptance: The request for approval of the source of supply shall include the location, manufacturing process, handling and storage methods for the material. Mineral filler shall conform to the requirements of AASHTO M-17.

2.4 LIQUID BITUMINOUS MATERIALS:

- A. Performance grade (PG) binder.
 1. Material shall have uniformly mixed and blended liquid bituminous materials that are free of contaminants such as fuel oils and other solvents. Such materials shall be properly heated and stored to prevent damage or separation. PG binders used in the production of bituminous materials shall be approved by Engineer. PG binders that are modified with fillers, extenders, reinforcing agents, adhesion promoters, additives, and thermoplastic polymers shall be approved for use only with the prior written approval from Engineer.
 2. Basis of Acceptance: The request for approval of the source of supply shall list the location where the materials will be produced, and manufacturing, processing, handling and storage methods along with necessary certification in accordance with AASHTO R-26. The PG binder utilized for the production of bituminous materials shall consist of the grade specified in the Contract when tested in accordance with AASHTO M-320 and AASHTO R-29.
- B. Cut-backs (medium cure type).
 1. The liquid petroleum materials for this item shall be produced by fluxing an asphalt base with appropriate petroleum distillates to produce the grade specified.
 2. Basis of Acceptance: The request for approval of the source of supply shall be submitted at least seven days prior to its use listing the location where the materials will be produced, and manufacturing, processing, handling and storage methods. The liquid asphalt shall be MC-250 conforming to AASHTO M-82.
- C. Emulsions

1. Emulsified asphalt shall be homogeneous and not be used if exposed to freezing temperatures.
2. Basis of Acceptance: The request for approval of the source of supply must include the location where the materials will be produced, and manufacturing, processing, handling and storage methods.
 - a. Emulsified asphalts shall conform to the requirements of AASHTO M-140. Materials used for tack coat shall be grade RS-1. When ambient temperatures are 80°F (27°C) and rising, grade SS-1 or SS-lh may be substituted if approved by Engineer.
 - b. Cationic emulsified asphalt shall conform to the requirements of AASHTO M-208. Materials used for tack coat shall be grade CRS-1. The settlement and demulsibility test will not be performed unless deemed necessary by the DRM. When ambient temperatures are 80°F (27°C) and rising, grade CSS-1 or CSS-lh may be substituted if approved by Engineer.

2.5 MIX DESIGN AND JOB MIX FORMULA (JMF)

A. Marshall Method - Class 1, 2, 3, 4 and 12

1. Requirements: The Marshall method shall be employed to develop a bituminous concrete mix design that includes a JMF consisting of target values for gradation and bitumen content for each class of bituminous concrete designated for the project in accordance with the latest Asphalt Institute’s MS-2 manual. Each class of bituminous concrete must meet the requirements as shown in the Table 2.
2. Basis of Acceptance: The Contractor shall submit to the Engineer a request for approval of the JMF in accordance with one of the methods described in c, d, and e below. Prior to the start of any paving operations the JMF and production percentage of bitumen must be approved by the Engineer, and the Contractor must demonstrate the ability to meet the approved JMF and production percentage of bitumen for each class of material. Additionally, the fraction of material retained between any two consecutive sieves shall not be less than 4%.
3. **Contractor shall** test each class of material for compliance with the submitted JMF and Table 2. The maximum theoretical density (Gmm) will be determined by AASHTO T-209 (modified). If the material does not meet the requirements, the JMF shall be adjusted within the ranges shown in Table 2 until an acceptable material is produced. All equipment, tests and computations shall conform to the Marshall method in accordance with AASHTO T-245 (modified).

Table 2
Ranges for Bituminous Concrete Hot Mix Asphalt Mixtures

Class	Class 1	Class 2	Class 3	Class 4	Class 12
Grade of PG Binder	PG 64-22	PG 64-22	PG 64-22	PG 64-22	PG 64-22
Content (%)	5.0-6.5	5.0-8.0	6.5-9.0	4.0-6.0	7.5-10.0
Sieve Size	Percent Passing (%):				
2”	--	--	--	100	--
1”	100	--	--	--	--
¾”	90-100	--	--	60-80	--

BITUMINOUS CONCRETE PAVEMENT

½"	70-100	100	100	--	100
3/8"	60-82	90-100	95-100	42-66	98-100
¼"	--	--	--	--	--
No. 4	40-65	55-80	65-87	30-55	80-95
No. 8	28-50	40-64	40-70	20-40	60-95
No. 30	10-32	16-36	20-40	--	20-60
No. 50	6-26	8-26	10-30	5-18	10-40
No. 200	3-8	3-8	3-8	0-5	3-10
Additionally, the fraction of material retained between any two consecutive sieves shall not be less than 4%.					
Material Temperature:					
Degrees F (°F)	325 max.				
Aggregate (°F)	280-350				
Mixtures (°F)	265-325				275-325
Voids (%)	3.0-6.0	2.0-5.0	0-4.0	-	0-5.0
Stability (lbs min.)	1200	1000	1000	-	1000
Flow (inches)	0.08-0.15	0.08-0.15	0.08-0.18	-	0.08-0.15
VMA (%-min.)	15:16	-	-	-	-

4. An approved JMF from the previous operating season may be acceptable to the Engineer provided that there are no changes in the sources of supply for the coarse aggregate, fine aggregate, recycled material (if applicable) and the plant operation had been consistently producing acceptable material.
5. Contractor shall not change sources of supply after a JMF has been approved. Before a new source of supply for materials is used, a new JMF shall be submitted to the Engineer for approval.

B. Marshall mixture (virgin)

1. For Bituminous concrete materials that contain no recycled material, the limits prescribed in Table M.04.01 govern. Contractor shall submit to the Engineer for approval, a JMF with the individual fractions of the aggregate expressed as percentages of the total weight (mass) of the mix and the source(s) of all materials. The JMF shall indicate two bitumen contents; the JMF target percentage and a production percentage (actual amount added to mix) of bitumen for each mix class by total weight (mass). For surface course Class 1, a 0.45 power gradation chart shall also be submitted on which is plotted the percentage passing each sieve. The JMF shall also indicate the target temperature of completed mixture as it is dumped from the mixer.

2.6 BITUMINOUS CONCRETE BINDER COURSE

- A. ConnDOT Bituminous Class 1.

2.7 BITUMINOUS CONCRETE TOP/FINISH COURSE

- A. ConnDOT Bituminous Class 2.

2.8 BITUMINOUS CONCRETE CURBING

- A. ConnDOT Bituminous Class 3.

2.9 BITUMINOUS CONCRETE SIDEWALKS

- A. ConnDOT Bituminous Class 2.

2.10 EQUIPMENT

- A. Maintain equipment in satisfactory operating condition and correct breakdowns in a manner that will not delay or be detrimental to progress of paving operations.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall install all pavements as specified in the location and to the grades as shown on the Drawings and/or approved by Engineer. Materials, methods of construction, and type and thickness of pavement courses shall be as shown on the Details of the Drawings and as specified herein.
- B. Owner and its representatives shall have access to all parts of the Work under construction at all times.

3.2 PREPARATION FOR PAVEMENT INSTALLATION

- A. Remove loose material from compacted base material surface immediately before proofrolling.
- B. Proof roll prepared base material surface to check for areas requiring additional compaction and areas requiring removal and recompaction.
- C. Do not begin paving work until deficient base material areas have been corrected and are ready to receive paving.
- D. Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to insure that all such items have been correctly positioned and set to the proper slope and elevation. All covers and grates are to be set flush with the required finished surface. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of these appurtenances. All correctional work that may be necessary, as determined by Engineer, shall be performed at the Contractor's expense.
- E. All vertical surfaces of structures and existing concrete surfaces in contact with new bituminous pavement shall be painted with a uniform coating of an approved bituminous emulsion material. Extreme care shall be exercised in the application of this material to prevent splattering or staining of surfaces that are to be exposed after the Work is completed. Surfaces that are stained as a result of the Contractor's operation shall be repaired and/or replaced to the satisfaction of Engineer at Contractor's expense.
- F. Bituminous paving shall not be applied until the Engineer inspects and approves the finished base.
- G. All existing paved surfaces to be overlaid must be thoroughly cleaned by a self-propelled sweeper. Areas inaccessible by power sweeper shall be broom swept until all non-pavement surface matter is removed.

3.3 TRANSPORT

- A. Mixture shall be transported from the mixing plant in trucks that have previously been cleaned of all foreign material and that have no gaps through which material might inadvertently escape. The use of kerosene, gasoline, fuel oil, or similar products for the coating of the inside of truck bodies is prohibited. Truck body coating and cleansing agents must not have a deleterious effect on the transported materials. If such agents are applied, truck bodies shall be raised immediately prior to loading to remove any excess agent.
- B. Loaded trucks shall be tightly covered with waterproof covers acceptable to the Engineer. Mesh covers are prohibited. The front and rear of the cover must be fastened to minimize air infiltration.
- C. Do not exceed legal weight limits.

3.4 APPLICATION

- A. Tack Coat
 - 1. Apply to contact surfaces of all portland cement concrete surfaces and surfaces abutting or projecting into bituminous concrete pavement.
 - 2. Apply tack coat to existing bituminous concrete surfaces at match points and where indicated on the drawings.
 - 3. Apply at a minimum rate of 0.05 gallons per square yard of surface.
 - 4. Allow to dry until at proper condition to receive paving.

3.5 PLACING AND COMPACTING

- A. Prior to the placement of the bituminous concrete, the underlying base course shall be brought to the plan grade and cross section within the allowable tolerance. Immediately before placing the mixture, the area to be surfaced shall be cleaned by brooming or by other means acceptable to the Engineer. Place bituminous concrete mixture on completed, compacted base surface, spread, and strike off.
- B. Whenever possible, all pavement shall be spread by a self-propelled finishing machine. At inaccessible or irregular areas, pavement may be placed by hand methods. The hot mixture shall be spread uniformly to the required depth with hot shovels and rakes. After spreading, the hot mixture shall be carefully smoothed to remove all segregated course aggregate and rake marks. Rakes and lutes used for hand spreading shall be of the type designed for use on asphalt mixtures. Loads shall not be dumped faster than they can be properly spread. Workers shall not stand on the loose mixture while spreading.
- C. Paving Machine Placement: Apply successive lifts of bituminous concrete in transverse directions with the surface course placed in the direction of surface-water flow. Place in typical strips not less than 10'-0" wide.
- D. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construction joints shall have the same texture, density, and smoothness as other sections of bituminous concrete courses. Clean contact surfaces and apply tack coat.
- E. The mixtures shall be placed and compacted to provide a smooth and dense surface with a uniform texture. When overtaken by sudden storms, the Engineer may permit placement of

the bituminous concrete to continue up to the quantity of material that is in transit from the plant.

- F. The mixture shall be placed at a temperature that is within 25°F of the approved job mix formula.
- G. Before rolling is started, the mat shall be checked for defects in material or placement. Such defects shall be corrected to the satisfaction of the Engineer. Where it is impracticable due to physical limitations to operate the paving equipment, the Engineer may permit the use of other methods or equipment. Where hand spreading is permitted, the mixture shall be placed by means of suitable shovels and other tools, and in a uniformly loose layer at a depth that will result in a completed pavement having the designed depth. Any deviation from standard crown or section shall be immediately remedied by placing additional material or removing surplus as directed by the Engineer. The Engineer may direct that other means of spreading be used to ensure a better control of the depths of material and the finished surface.
- H. A thin uniform coating of tack coat shall be applied to the pavement immediately before overlaying and be allowed sufficient time to break (set). All surfaces that have been in place longer than five calendar days shall have an application of tack coat. A tack coat shall be applied to all contact surfaces such as gutters, manholes and concrete barriers. The tack coat shall be applied by a non-gravity pressurized spray system that results in uniform overlapping coverage at an application rate of 0.05 to 0.15 gallons per square yard. Gravity-fed systems are not acceptable for tack coat application. The Engineer must approve the equipment and the method of measurement prior to use. The material for tack coat shall not be heated in excess of 160°F and shall not be further diluted.
- I. Refueling of equipment is prohibited in any location on the paving project where fuel might come in contact with bituminous concrete mixtures already placed or to be placed. Solvents for use in cleaning mechanical equipment or hand tools shall be stored clear of areas paved or to be paved. Before any such equipment and tools are cleaned, they shall be moved off the paved or to-be-paved area; and they shall not be returned for use until after they have been allowed to dry.
- J. Immediately before placing bituminous concrete on a waterproofing membrane, the membrane shall be swept clean. If the membrane is damaged it shall be repaired by patching as directed by the Engineer.
- K. Temporary and permanent transverse joints shall be formed by saw-cutting a sufficient distance back from the previous run, existing bituminous concrete pavement, or bituminous concrete driveways to expose the full depth of the course. On any cold joint, immediately prior to additional bituminous concrete materials being placed, a brush of tack coat shall be used on all contact surfaces.
- L. The longitudinal joint shall be offset at least six inches from the joint in the course immediately below. The joint in the final surface shall be at the centerline or at lane lines.

3.6 ROLLING AND COMPACTION

- A. In general, rolling shall consist of initial or breakdown rolling, intermediate rolling and final or finish rolling. The contractor shall furnish a sufficient number and type(s) of rollers for each paving machine to properly compact the mat. When operating the roller in the vibratory (dynamic) mode, the operator shall maintain a minimum of ten to twelve impacts per foot. All vibratory rollers shall be shut off from the vibrating mode when reversing directions and

be equipped with automatic reversing eccentrics (weights). The use of a vibratory roller in the dynamic or vibratory mode is prohibited on concrete structures such as bridges and catch basins.

- B. If the Engineer determines that the use of vibratory compaction equipment may damage highway components, utilities or adjacent property, the Contractor shall provide alternate compaction equipment to meet specification requirements unless otherwise approved by the Engineer. The completed pavement course on roadways and bridges will have the mat and longitudinal joints tested for compaction in accordance with the "Density Testing Procedure" established by the Department's Director of Research and Materials. Each course placed at a depth of one and one-half inches or greater shall have the mat and longitudinal joints compacted to a minimum of 92.0 percent and no more than 97.0 percent density as determined by AASHTO T209 (modified). Class 4 bituminous concrete is excluded from the joint density requirements.
- C. Surface Tolerance: The Contractor shall perform random spot-checks with a contractor-supplied ten-foot straightedge placed parallel to the centerline of the road to verify surface tolerances. The final surface course will not vary more than 1/4 inch from a ten-foot straightedge and 3/8 inch for all other courses. Such tolerance will apply to all paved areas including bridge approaches, headers, and existing pavement. Any irregularity of the surface exceeding these limits shall be corrected.
- D. Protection of the Work: All sections of the newly finished pavement shall be protected by the Contractor from damage by the Contractor's equipment and traffic.
- E. Corrective Work Procedures: Any portion of the completed pavement determined by the Engineer to be defective in surface texture, density or composition, or that does not comply with the requirements of the specifications shall be corrected at the expense of the Contractor. Any corrective courses placed as the final wearing surface shall not be less than one and one-half inches in depth after compaction.

3.7 DEFICIENT PAVEMENT

- A. If pavement placed by the Contractor does not meet the specifications, and the Engineer requires its replacement or correction, the Contractor shall:
 - 1. Propose a corrective procedure to the Engineer for review and approval prior to any corrective work commencing. The proposal shall include:
 - a. Limits of pavement to be replaced or corrected, indicating stationing or other landmarks that are readily distinguishable.
 - b. Schedule.
 - c. Construction method and sequence of operations.
 - d. Methods of maintenance and protection of traffic.
 - e. Material sources.
 - f. Names and telephone numbers of supervising personnel.
 - 2. Perform all corrective work in accordance with the Contract and the approved corrective procedure.

3.8 JOINTS AND CRACKS IN BITUMINOUS CONCRETE PAVEMENT

A. Cracks.

1. Control of Joint Seal Material: Material that is heated or cooled beyond the manufacturer's specified temperature range shall be discarded.
2. Sawing and Sealing Joints in Bituminous Concrete Pavement: Work under this item shall consist of making a straight-line saw cut transversely across the final course of bituminous concrete pavement directly over the new and existing Portland Cement concrete (PCC) transverse joints. The sawing and sealing of joints shall be completed for bituminous concrete pavements with a total depth of three inches or greater. The saw cut shall be immediately sealed with a joint seal material. The sawing and sealing shall commence within one week of the completion of any final course of pavement and be a continuous operation until all joints have been completed. If the final course of pavement will not be completed prior to winter shutdown, each exposed course shall have a ¼ inch by ¼ inch kerf cut above the new and existing transverse joints. The kerf shall be cut with a saw or abrasive wheel approved by the Engineer. The kerf cut shall not be sealed. The kerf cuts at the joints will be paid under the contract item "Kerf Cut in Bituminous Concrete Pavement".
3. Prior to the paving operation, the Contractor shall establish sufficient controls to locate each transverse joint. This work shall include setting markers at each joint to reference its location and alignment, and having each of these markers tied and referenced. A written procedure for this work shall be submitted to the Engineer for review prior to commencement of such work.
4. The saw cut will be made by using diamond saw blades with a gang blade arrangement in order to achieve the joint detail as shown on the plans. The saw cut will be in a straight line across the pavement directly over the joint. Transverse joints shall extend to a point two feet beyond the underlying PCC pavement. The sawed joints shall be cleaned with compressed air to the satisfaction of the Engineer.
5. Immediately following the cleaning, the joint seal material shall be installed. When cooled, the top of the sealant material shall be recessed a minimum of 1/16 inch (1.6 millimeters) but not greater than 1/8 inch (3.2 millimeters) below the adjacent pavement surface. The roadway shall not be opened to traffic until the material has become tack free. Any depression in the sealer greater than 1/8 inch (3.2 millimeters) shall be brought up to the specified limit by further addition of joint seal material. Care shall be taken during the sealing operation to ensure that overfilling and spilling of material is avoided.
6. Any reflective cracking attributable to improper joint referencing or construction shall be repaired at the expense of the Contractor, in a manner approved by the Engineer for a period of one year from the date of completion of any sawed and sealed portion of final pavement.

3.9 CLEANING AND SEALING JOINTS AND CRACKS IN PAVEMENT

- A. Work under this item shall consist of cleaning existing joints and cracks of all dirt, dust, loose joint material, and all deleterious matter with compressed air to the satisfaction of the Engineer. After a sufficient number of joints and cracks have been cleaned so as to ensure a continuous operation, all joints and cracks shall be sealed with joint seal material.

3.10 CUT BITUMINOUS CONCRETE PAVEMENT

- A. Make a straight-line cut in the bituminous concrete pavement to the lines delineated on the Drawings or as directed by the Engineer. The cut shall provide a straight, clean, vertical face with no cracking, tearing or breakage along the cut edge.

3.11 BITUMINOUS CONCRETE SIDEWALKS

- A. Forms: Where walls, curbing or other suitable permanent supports are not present, satisfactory forms shall be installed to assist in securing alignment and adequate compaction of the base and surface courses. All forms shall be removed and backfilled with proper material.
- B. Placing Bituminous Concrete: The bituminous concrete walk surface shall be laid in a single course to a depth after compaction of 4 inches, unless otherwise detailed or directed.
- C. Unless otherwise directed, the walk shall have a minimum pitch of 3/16 of an inch per foot of width to provide for proper drainage.
 - 1. Spreading Mixture. The mixture shall be dumped, as needed, in wheelbarrows or an approved steel dump sheet outside the areas on which it is to be placed. It shall then be immediately distributed into place by means of shovels and raked into a uniformly loose layer to the full width required and of such depth that, when the Work is completed, it shall conform to the grade and surface contour required.
 - 2. Rolling. The surface shall be rolled with a self-propelled, tandem roller weighing not less than 1-1/2 tons and not more than 5 tons. In places inaccessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers weighing not less than 50 pounds and having a tamping face not exceeding 100 square inches.
 - 3. Testing Surface. When tested with a 10-foot straightedge placed parallel to the centerline of the courses, there shall be no deviation from a true surface in excess of 1/4 of an inch.

3.12 FIELD QUALITY CONTROL

- A. Independent Testing Laboratory: Contractor shall retain a third-party testing entity to perform construction testing of in-place bituminous concrete courses for compliance with requirements for thickness and surface smoothness. Contractor shall pay all costs for testing.
- B. Bituminous surface and base courses shall be randomly cored at a minimum rate of one core for every 20,000 square feet of paving. However, no less than three cores in light duty areas and three cores in heavy duty areas shall be obtained. Coring holes shall be immediately filled with full-depth asphalt or with concrete. Bituminous concrete pavement samples shall be tested for conformance with the mix design.
- C. Grade Control: Establish and maintain required lines and elevations.
- D. Thickness: In-place compacted thickness shall not be less than the thickness specified on the drawings. Areas of deficient paving thickness shall receive a tack coat and a minimum 1" thickness, at the discretion of Engineer, until specified thickness of the course is met or exceeded at no additional expense to Owner.
- E. Surface Smoothness: Testing shall be performed on the finished surface of each bituminous concrete course for smoothness, using 10'-0" straightedge applied parallel with, and at right

angles to centerline of paved area. The results of these tests shall be made available to Engineer upon request. Surfaces will not be acceptable if exceeding following tolerances for smoothness:

1. Bituminous Concrete Class 4: tolerance +/- 3/4 inch
 2. Bituminous Concrete Class 1, 2 and 12: tolerance +/- 1/2 inch
- F. Check surfaces areas at intervals necessary to eliminate ponding areas. Remove and replace unacceptable paving as directed by Engineer.
- G. Compaction: Field density tests for in-place materials shall be performed by examination of field cores and shall have a minimum compacted density of 95% of laboratory Marshall Density in accordance with one of the following standards:
1. Bulk Specific Gravity and Density of Compacted Bituminous Mixture Using Paraffin-Coated Specimens: ASTM D1188.
 2. Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens: ASTM D2726.
 3. Rate of testing shall be one core per 20,000 square feet of pavement, with a minimum of 3 cores from heavy-duty areas and 3 cores from standard-duty areas. Cores shall be cut from areas representative of the project.
 4. Areas of insufficient compaction shall be delineated, removed, and replaced in compliance with the specifications at no expense to the Owner.

3.13 MEETING EXISTING PAVEMENTS

- A. Where new pavements are to meeting existing pavements, the Contractor shall saw cut the existing pavements so that there will be a vertical butting surface between the old and new pavements. Sawcutting of existing pavements shall be along neat, straight and even lines, and shall be done in such a manner so as not to damage the adjacent pavement which is to remain.
- B. Full-Depth Pavement - The existing pavement shall be sawcut by an approved method for the full depth of the pavement prior to placement of any new pavement. The existing bituminous surface shall be trimmed to a neat true line with straight vertical edges free from irregularities, and the trimmed edges shall be treated with a light coating of asphaltic emulsion immediately prior to the installation of the new abutting bituminous concrete surface course to provide a bond between the old and new pavement. The new compacted pavement surface shall be finished flush with the adjacent pavement.
- C. Bituminous Concrete Overlays: A line shall be cut by an approved method where the new pavement is to meet the existing pavement. The existing bituminous surface shall be trimmed to a neat true line with straight vertical edges free of irregularities for a minimum depth of one and one half inches. Sufficient pavement shall then be ground by machine method leaving a tapered Section of pavement ground one and one-half inches thick at the pavement butt and feathered back to meet the existing pavement surfaces. The ground, tapered transition section width shall be two feet at driveways and six feet in roadways and parking areas. Immediately prior to the placement of the bituminous concrete overlay the trimmed edges of the existing pavement shall be treated with a coating of asphaltic emulsion to bond the new pavement to the old pavement. The new pavement surface shall be finished flush with the adjacent

pavement. Surface seam of pavement joint shall be painted with emulsion and covered with sand or proper material to absorb excess emulsion.

END OF SECTION

SECTION 32 1416 - UNIT PAVERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes
 - 1. Preparation of base course.
 - 2. Installation of unit pavers.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.
- C. Contractor is responsible for all health and safety.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. United States Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM).
 - 1. ASTM C33 - Standard Specification for Concrete Aggregates.
 - 2. ASTM C 97 - Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone.
 - 3. ASTM C 119 - Terminology Relating to Dimension Stone.
 - 4. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 5. ASTM C 170 - Test Method for Compressive Strength of Dimension Stone.
 - 6. ASTM C270 - Standard Specification for Mortar for Unit Masonry.
 - 7. ASTM C615 - Standard Specification for Granite Dimension Stone.
 - 8. ASTM C 880 - Test Method for Flexural Strength of Dimensional Stone.
 - 9. ASTM C 936 - Standard Specifications for Solid Interlocking Concrete Paving Units.
 - 10. ASTM C1272 - Standard Specification for Heavy Vehicular Paving Brick.
- D. National Building Granite Quarries Association, Inc.

1.3 SUBMITTALS

- A. Product Data: Submit specifications and other data for all materials required, including, but not limited to aggregates, cement, mortar coloring additive, latex polymer modifier for mortar setting bed, bonding compound, and certification that unit pavers comply with specified requirements. Include detailed instructions for handling, storage, installation and protection of all items.
- B. Samples
 - 1. Sufficient samples of unit pavers shall be submitted to the Design Professional through Contractor.
 - 2. Each sample set shall include three samples.
 - 3. Sample set shall show anticipated range of color, natural variations of grain structure, inclusions and any other visual characteristics to be expected in the final installation.
 - 4. Approved sample set shall establish the standard by which the work will be judged.

1.4 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

1.5 STORAGE AND HANDLING

- A. Storage
 - 1. Transportation carrier shall use appropriate methods to ensure materials are properly supported, stacked, and restrained during transport.
 - 2. Carefully pack, band and load unit pavers for shipment on wood pallets or skids. Pallets and skids shall be stacked in such a manner as to evenly distribute the weight of the paver and to prevent breakage, cracking, and other damage to the paver. Protect pavers during storage and construction against moisture, soiling, staining and physical damage. No material, which may cause staining, or discoloration may be used for blocking, packing or dunnage. Use polyethylene or other suitable plastic to separate dissimilar materials.
 - 3. Deliver packaged materials to the Project Site in their original, unopened package or container-bearing label clearly identifying manufacturer's name, brand name, material, weight or volume, and other pertinent information. Packaged materials shall be stored in their original, unbroken package or container in a weather tight and dry place until ready for use in the work.
 - 4. Deliver unpackaged aggregates in bulk and store to avoid excessive segregation, contamination with other materials or other size aggregates, or freezing.
- B. Handling
 - 1. Handle unit pavers so as to prevent chipping, breakage, marring, soiling and other damage. Do not use pinch or wrecking bars without protecting edges of stone with wood or other suitable material. Cracked, badly chipped, or stained units will be rejected and shall not be employed in the work.

- C. Protect grout and mortar materials from deterioration due to moisture and/or temperature. Store in a dry location or in waterproof containers. Protect liquid components from freezing.

1.6 JOB CONDITIONS

- A. Existing Conditions: Examine all work that the work of this section is contingent upon and report any deficiencies to Landscape Architect. Commencement of work will be construed to mean complete acceptance of the preparatory work of others.
- B. Cold weather protection:
1. Frozen Materials: Do not use frozen materials or materials mixed or coated with ice or frost.
 2. Frozen Work: Do not build on frozen subgrade.
 3. Do not use frozen materials or materials mixed or coated with ice or frost. Do not use salt to thaw ice or for any other reason.
 4. During all seasons, protect partially completed work against weather when work is not in progress.

PART 2 PRODUCTS

2.1 UNIT PAVER BASE

- A. Clean, non-plastic, natural or manufactured from crushed rock, ASTM C33. Material shall be free of deleterious or foreign matter. Do not use limestone screenings or stone dust. Unit Paver Base shall be graded as follows:

Gradation of Brick Paver Base

Sieve Size	Percent Passing
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	85 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (600 mm)	25 to 60
No. 50 (0.300 mm)	10 to 30
No. 100 (0.150 mm)	2 to 10

2.2 SAND

- A. Sand shall consist of clean, hard, durable, uncoated particles of quartz or other rock. It shall not contain more than 3% of material finer than a #200 sieve.
- B. Organic Impurities: Fine aggregate subjected to the colorimetric test shall not produce a color darker than Gardner Color Standard No. 11, using AASHTO T 21. If the fine aggregate fails to meet this requirement, the provisions of AASHTO M 6, Section 5.2, will govern.
- C. Sand shall be uniformly graded as follows:

Gradation of Sand

Sieve	Percent Passing by Weight
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

- D. The above gradation represents the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from any source. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample will be rejected.

2.3 PAVING UNITS - CONCRETE

- A. Concrete Units: ASTM C 936.

2.4 PAVING UNITS – GRANITE

- A. Granite Unit Pavers: ASTM C615.

- B. All granite shall be of standard architectural grade, free of cracks, seams, or starts, which may impair its structural integrity or function. Color or other visual characteristics indigenous to the particular material and adequately demonstrated in the sampling or mock-up phases will be accepted provided they do not compromise the structural or durability capabilities of the material. Texture and finish shall be within the range of samples approved by Engineer.

- C. Source Quality Control

1. Provide granite, which complies with recommendations of the National Building Granite Quarries Association, Inc.
2. Obtain each type of granite from a quarry with a consistent color range and texture for each type and color of granite throughout the Work. Do not change the quarry or suppliers of materials during the course of the Work.

2.5 PAVING UNITS- TRAFFIC BOUND SURFACE

- A. Clay Units: ASTM C1272.
- B. Concrete Units: Concrete Units: ASTM C 936.

2.6 SAND JOINT FILLER

- A. Sand and cement mixture: One part Portland cement, three parts sand.
1. Portland Cement: Cement: ASTM C 150, Type I, IA, II, or IIA. One brand and type of cement shall be used for formed concrete having exposed-to-view finished surfaces.
 2. Sand: Clean, washed, uniformly well-graded masonry sand, ASTM C144, except that the fineness modulus shall be 2.25 ± 0.10 . Sand shall be from a single source.
- B. Colorant: Mineral oxide pigment and shall be certified by the supplier to be resistant to alkali, light and weather and shall be of a chemical composition unaffected by cement and free of water and soluble salts. Color: As specified or shown on the Drawings and approved in samples by Engineer.

2.7 JOINT STABILIZING SAND

- A. Polymeric Sand, properties and gradation conforming to ASTM C-136.
1. Sand and water-activated polymer mixture.
 2. Color: Grey.
 3. Gradation:

Gradation of Polymeric Sand Joint Stabilizer

Sieve Size	Natural Sand Percent Passing	Manufactured
No. 4 (4.75 mm)	100	100
No. 8 (2.36 mm)	95 to 100	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100
No. 30 (600 mm)	40 to 75	40 to 75
No. 50 (0.300 mm)	10 to 35	20 to 40
No. 100 (0.150 mm)	2 to 15	10 to 25
No. 200 (0.075 mm)	0 to 10	0 to 10

PART 3 EXECUTION

3.1 GENERAL

- A. Do not use paver units with excessive chips, cracks, voids, discoloration or other defects, which might be visible or cause staining in finished work.
1. Cut paver units with motor-driven saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern shown and to fit adjoining work neatly. Use full units without cutting wherever possible.
 2. Set paver units in patterns shown on drawings and with uniform joints of widths indicated herein.
 3. Surface Tolerances: Maintain the surface plane for finished paving not exceeding a tolerance of $\pm 1/4"$ in 10 feet when tested with a 10 foot straight edge.

3.2 PREPARATION OF SUBBASE/BASE

- A. All soft and yielding material, and other portions of the subbase which will not compact readily when rolled, vibrated or tamped, shall be removed and replaced with suitable material. Compact subbase to 95% maximum dry density at optimum moisture content, ASTM D 1557 Method C. Density indicated is minimum required.
 - 1. Protect subgrade from damage. At all times, the subgrade surface shall be kept in such condition that it will drain readily and correctly.
- B. If additional material is required to bring subgrade to specified elevations, utilize Granular Fill as Specified in Section 31 23 10 – Earthwork. If additional material is added above subgrade, compact additional material to 95% maximum dry density at optimum moisture content. Density indicated is minimum required.

3.3 UNIT PAVER BASE

- A. After compaction of subbase, install Unit Paver Base in the thickness indicated on the drawings.
- B. Compact Unit Paver Base to 95% maximum dry density at optimum moisture content, ASTM D 1557 Method C. Density indicated is minimum required.
- C. Finish grade of Unit Paver Base shall be within one-half (1/2) inch of required elevation for setting pavers.
- D. Protect Unit Paver Base from damage. If base becomes rutted or displaced, re-grade as required.

3.4 SAND SETTING BED

- A. Utilize sand setting bed to fine grade to achieve required elevation for setting pavers.

3.5 INSTALLATION

- A. Thoroughly clean all paving units of dirt debris or other contaminants.
- B. Install paving units carefully by hand as shown on the Drawings.
 - 1. Before setting, paver shall be clean and free of dirt and foreign matter on all sides.
 - 2. Each piece shall be carefully bedded in base and tapped home with a rawhide or hardened rubber mallet to a full and solid bearing. Particular care shall be exercised to equalize joint openings.
 - 3. Pavers shall be set true to the required lines and grades.
 - 4. Protect newly laid paving units with panels of plywood or similar material.
 - 5. Do not allow workers on the installed pavers.
 - 6. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting the alignment of paving units.
- C. Joint Treatment: Place paving units with hand tight joints.
 - 1. Fill joints with joint stabilizing sand per manufacturer's instructions.

2. Brush joint stabilizing sand to completely fill joints, and ensure no materials remains on paver surface.
3. Following application of dry product, fog water per manufacturer's instructions.

3.6 PROTECTION

- A. Contractor shall protect all of the work of this section and keep it in first class condition until the completion of the contract. Exercise particular care to prevent damage to the surface of the pavers.
- B. Remove and replace paver units, which are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units, which do not match adjoining paver units. Provide new matching units, install as specified and point-up joints to eliminate evidence of replacement.

END OF SECTION

SECTION 32 1623 - CURBING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Bituminous concrete lip curb.
- B. Work shall also include all associated items and operations necessary and required to complete the installations, including, but not limited to, surface preparation, finishing and cleanup.
- C. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. United States Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004.
- D. American Society for Testing and Materials (ASTM)
 - 1. ASTM C33 - Standard Specification for Concrete Aggregates.
 - 2. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
 - 3. ASTM C150 - Standard Specification for Portland Cement.
 - 4. ASTM D235 - Standard Specification for Mineral Spirits (Petroleum Spirits).
 - 5. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes
 - 6. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 7. ASTM C309 - Standard Specification for Liquid Membrane - Forming Compounds for Curbing Concrete.
 - 8. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.
 - 9. ASTM C989 - Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.

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10. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
 11. ASTM D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
- E. American Concrete Institute (ACI)
1. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.
- F. American Association of State High and Transportation Officials (AASHTO)
1. AASHTO M 6 - Standard Specification for Fine Aggregate for Portland Cement Concrete.
 2. AASHTO M 85 - Standard Specification for Portland Cement (Chemical and Physical).
 3. AASHTO M 133 - Standard Specification for Preservatives and Pressure Treatment Processes for Timber.
 4. AASHTO M 213 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
 5. AASHTO M 233 - Standard Specification for Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
 6. AASHTO M 240 - Standard Specification for Blended Hydraulic Cement.
 7. AASHTO T11 - Standard Method of Test for Materials Finer Than 75-um (No. 200) Sieve in Mineral Aggregates by Washing.
 8. AASHTO T21 - Standard Method of Test for Organic Impurities in Fine Aggregate for Concrete.
- 1.3 SUBMITTALS
- A. Submit Shop Drawings, manufacturer's literature, material certificates or other data indicating compliance with these Specifications.
- 1.4 DELIVERY, STORAGE AND HANDLING
- A. Stone and precast curb units shall be delivered to the job adequately protected from damage during transit.
 - B. Curbing shall be protected against staining, chipping, and other damage. Cracked, badly chipped, or stained units will be rejected and shall not be employed in the Work.

PART 2 PRODUCTS

2.1 BITUMINOUS CONCRETE LIP CURBING

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- A. Bituminous concrete for curbing shall be as specified in Section 321216 – Asphalt (Bituminous Concrete) Pavement.

2.2 TRANSITION SECTIONS

- A. Horizontal transition sections shall be provided at all locations where curb sections change (i.e., vertical to sloped). Vertical transition sections shall also be provided for precast curb sections at handicapped ramps to create a smooth transition with a doweled joint. Vertical transition sections for stone curb shall be made as shown on the Drawings.

PART 3 EXECUTION

3.1 GENERAL

- A. Trenching, excavation, backfilling, and compaction shall be completed in accordance with Section 31 2310 - Earthwork, except as modified within this Section.
- B. Cement Mortar Bedding, if required, shall be placed as indicated in details in accordance with Section 03 3200 - Site Cast-In Place Concrete.

3.2 BITUMINOUS CONCRETE LIP CURB

A. General Requirements

1. Bituminous curbing shall be constructed by the use of an approved self-propelled extruding curb machine equipped with a material hopper, distributing screw and curb forming device capable of placing the bituminous mixture to the required lines, grades and proper curb cross-section. Prior to the placement of any curb, Contractor shall submit a detail of the cross-section of the curb mold that he proposes to use to Engineer for approval.

B. Surface Preparation

1. When curbing is to be placed on existing bituminous pavements, concrete pavements or newly laid bituminous pavements which have been in place more than twenty-four (24) hours, the surface on which the curb is to be placed shall be swept and cleaned, thoroughly dried, and immediately prior to placement of the curb, the surface to be occupied by the curb shall be given an application of tack coat material. Particular care shall be exercised to prevent spread of tack coat material beyond the area to be occupied by the curb. Recently placed bituminous concrete pavement, which have been placed less than twenty-four (24) hours prior to placement of the curb need only be thoroughly swept and cleaned.

C. Placing and Compaction

1. The hot bituminous mixture shall be placed in the hopper of the curb paver without segregation and extruded through the mold form to provide the proper compaction and surface texture.
2. The curb paver shall be properly supported and weighted during operation along the edge of the pavement and shall be guided along string or chalk lines to maintain the proper alignment and level of the completed curb.

3. Any portions of the completed curb, which are not satisfactorily compacted, or show signs of sagging, cracking, or distortion, or do not conform to the required lines, grades or cross-section for any reason, and which cannot be satisfactorily repaired during construction, shall be removed and replaced at no additional cost to the Owner.
- D. Joints: Bituminous curb construction shall be a continuous operation in one direction only, to eliminate frequent joints. When the placing of the curb is discontinued for a length of time that permits the mixture to become chilled, the curb shall be cut in a true vertical plane and the exposed end painted with a thin uniform coat of hot asphalt cement just prior to placing the fresh curb mixture against the previously constructed curb to insure a continuous bond.

END OF SECTION 321623

SECTION 321723 - PAVEMENT MARKINGS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Temporary or permanent painted pavement markings, including but not limited to center lines, lane lines and shoulder lines, stop bars, crosswalks, parking stalls, lane arrows, legends, markings within gore areas, and painting of paved islands or medians.
 - 2. Temporary plastic pavement marking tape.
 - 3. Black line mask pavement marking tape.
- B. Maintain access for vehicular and pedestrian traffic as required for other construction activities. Utilize flagmen, barricades, warning signs, and warning lights as required.
- C. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 SUBMITTALS

- A. Submit material specifications and shop drawings for all materials furnished under this Section.
- B. Submit material certificates signed by the material producer and Contractor, certifying that materials comply with these Specifications.

1.3 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. State of Connecticut Department of Transportation (ConnDOT)
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- C. Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction
- D. American Society for Testing and Materials (ASTM)
 - 1. ASTM C501 - Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser.
 - 2. ASTM D211 - Standard Specification for Chrome Yellow and Chrome Orange Pigments.
 - 3. ASTM D476 - Standard Classification for Dry Pigmentary Titanium Dioxide Products.
 - 4. ASTM D562 - Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer.

5. ASTM D605 - Standard Specification for Magnesium Silicate Pigment (Talc).
 6. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.
 7. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
 8. ASTM D711 - Standard Test Method for No-Pick-Up Time of Traffic Paint.
 9. ASTM D869 - Standard Test Method for Evaluating Degree of Settling of Paint.
 10. ASTM D1475 - Standard Test Method for Density of Liquid Coatings, Inks, and Related Products.
 11. ASTM D1763 - Standard Specification for Epoxy Resins.
 12. ASTM D2240 - Standard Test Method for Rubber Property- Durometer Hardness.
 13. ASTM D2486 - Standard Test Methods for Scrub Resistance of Wall Paints.
 14. ASTM D4060 - Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
 15. ASTM D4505 - Standard Specification for Preformed Retroreflective Pavement Marking Tape for Extended Service Life.
 16. ASTM E303 - Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester.
 17. ASTM G153 - Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.
- E. American Association of State High and Transportation Officials (AASHTO)
1. AASHTO M 247 - Standard Specification for Glass Beads Used in Traffic Paints.
- F. American Concrete Institute
1. ACI 503R - Use of Epoxy Compounds with Concrete.
- G. United States General Services Administration, Federal Specifications.
1. Federal Specification TT-P-1952D - Paint, Traffic and Air Field Marking, Water Emulsion Base.
- H. United States General Services Administration, Federal Standards.
1. Federal Standard No. 595 - Colors Used in Government Procurement.

1.4 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.
- B. Contractor shall furnish one technical expert, who shall be fully knowledgeable about all equipment operations and application techniques, to oversee the work of this Section.

PART 2 PRODUCTS

2.1 WATERBORNE PAVEMENT MARKING PAINT

A. General

1. White and yellow fast-drying waterborne pavement marking paint, low VOC, ready-mixed, one component, 100 percent acrylic, Federal Specification TT-P-1952D.
2. Paint shall be capable of being applied with paint striping equipment at ambient temperatures.
3. Weight per gallon shall not be less than 12.5 pounds/gallon when tested in accordance with ASTM D 1475.
4. Colors: ASTM D211 and per Federal Standard No. 595.

B. Manufacture

1. Paint shall be formulated and manufactured from first-grade raw materials and shall be free from defects and imperfections that might adversely affect the serviceability of the finished product. The materials shall not exhibit settling or jelling after storage in the sealed containers as received that will affect the performance of the products. The paint shall provide the proper anchorage, refraction and reflection for the finished glass spheres when applied as specified.

C. Composition

1. Composition of the paint shall be at the discretion of the manufacturer, provided that the finished product meets the requirements of any applicable Federal, State or Local regulations for products of this type and the requirements as follows:
 - a. Paint shall not contain more than 0.06% lead.
 - b. Total nonvolatile shall not be less than 70% by weight (mass).
 - c. Pigment shall be 45-55% by weight (mass).
 - d. Resin solids shall be composed of 100% acrylic emulsion polymer.
 - e. Volatile organic compounds shall not exceed 150 grams/liter, excluding water.
 - f. Closed-cup flash point shall not be less than 100°F (38°C), and weight per gallon shall not be less than 12.5 pounds/gallon when tested in accordance with ASTM D 1475.

D. Viscosity

1. Consistency of the paint shall not be less than 80, nor more than 90 Krieb units when tested in accordance with ASTM D562. The paint shall have good spraying characteristics when the material is heated to application temperature of 130°F to 145°F.

E. Flexibility

1. Paint shall not show cracking or flaking when subjected to the TT-P-1952D flexibility test in which the panels used shall be tin plates that are 3 inches x 5 inches in area and

35 - 31 U.S. Gauge in thickness. The tin panels shall be lightly buffed with steel wool and thoroughly cleaned with solvent before being used for tests.

F. Dry Opacity

1. Both white and yellow paints shall have a minimum contrast ratio of 0.96. Contrast ratio shall be determined by applying a wet film thickness of 0.005 inches (127 microns) to a standard hiding power chart. After drying, the black and white reflectance values shall be determined using a suitable reflectometer and the contrast ratio determined.

G. Bleeding

1. Paints shall have a minimum bleeding ratio of 0.97 when tested in accordance with FS TT-P-1952D.

H. Abrasion Resistance

1. No less than 210 liters of sand shall be required to remove paint film when tested in accordance with TT-P-1952D.

I. Color

1. Yellow: FS 595, No. 13538, latest issue.
2. White: No darker or yellower than FS 595, No. 17778, latest issue, when the material is placed in a type EH weatherometer for a period of 500 hours and weathered according to ASTM G153.
3. Color determination shall be made without beads, after a minimum of 24 hours. If not a visual match, the diffuse day color of the paint shall conform to the CIE Chromaticity coordinate limits as follows:

Paint CIE Chromaticity Coordinate Limits

	x	Y	x	y	x	y	x	y	Brightness
White	0.305	0.295	0.360	0.360	0.388	0.377	0.280	0.310	84.0 Min
Yellow	0.485	0.455	0.506	0.452	0.484	0.428	0.477	0.438	50.0 Min

4. Paint shall not discolor in sunlight and shall maintain colorfastness throughout its life, approximately two years.

J. Glass Bead Adhesion

1. Paint with glass beads conforming to M.07.30, applied at the rate of 6.0 pounds/gallon of paint, shall require not less than 150 liters of sand to remove paint film and glass beads.

K. Scrub Resistance

1. Paint shall pass 300 cycles minimum when tested in accordance with ASTM D2486.

L. Drying time

1. Reflectorized line shall dry to no pick up in 15 minutes or less as tested by ASTM D711 when applied at the ratio provided for specified glass spheres to paint (the paint at 15+ 1 mil (381 millimeters + 25 millimeters) wet film thickness equivalent to 100-115 square foot/gallon and the glass spheres at the equivalent rate of 6.0 pounds/gallon.

2.2 HOT-APPLIED WATERBORNE PAVEMENT MARKING PAINT

A. General

1. White and yellow fast-drying waterborne pavement marking paint, low VOC, ready-mixed, one component, 100 percent acrylic, Federal Specification TT-P-1952D.
2. Paint shall be capable of being applied with paint striping equipment at an application temperature of 130°F to 145°F.
3. Color: ASTM D211 and per Federal Standard No. 595.
4. Glass Beads: AASHTO M 247, Type 1.

B. Manufacture

1. Paint shall be formulated and manufactured from first-grade raw materials and shall be free from defects and imperfections that might adversely affect the serviceability of the finished product. The materials shall not exhibit settling or jellying after storage in the sealed containers as received that will affect the performance of the products. The paint shall provide the proper anchorage, refraction and reflection for the finished glass spheres when applied as specified.

C. Composition

1. Composition of the paint shall be at the discretion of the manufacturer, provided that the finished product meets the requirements of any applicable Federal, State or Local regulations for products of this type and the requirements as follows:
 - a. Paint shall not contain more than 0.06% lead.
 - b. Total nonvolatile shall not be less than 76% by weight (mass).
 - c. Pigment shall be 58-63% by weight (mass).
 - d. Resin solids shall be composed of 100% acrylic emulsion polymer.
 - e. Volatile organic compounds shall not exceed 150 grams/liter, excluding water.
 - f. Closed-cup flash point shall not be less than 100°F, and weight per gallon shall not be less than 12.5 pounds/gallon when tested in accordance with ASTM D 1475.

D. Viscosity

1. Consistency of the paint shall not be less than 80, nor more than 90 Krieb units when tested in accordance with ASTM D562. The paint shall have good spraying characteristics when the material is heated to application temperature of 130°F to 145°F.

E. Flexibility

1. Paint shall not show cracking or flaking when subjected to the TT-P-1952D flexibility test in which the panels used shall be tin plates that are 3 inches x 5 inches (76 millimeters x 127 millimeters) in area and 35 - 31 U.S. Gauge in thickness. The tin panels shall be lightly buffed with steel wool and thoroughly cleaned with solvent before being used for tests.

F. Dry Opacity

1. Both white and yellow paints shall have a minimum contrast ratio of 0.96. Contrast ratio shall be determined by applying a wet film thickness of 0.005 inches (127 microns) to a standard hiding power chart. After drying, the black and white reflectance values shall be determined using a suitable reflectometer and the contrast ratio determined.

G. Bleeding

1. Paints shall have a minimum bleeding ratio of 0.97 when tested in accordance with FS TT-P- 1952D.

H. Abrasion Resistance

1. No less than 210 liters of sand shall be required to remove paint film when tested in accordance with TT-P-1952D.

I. Color

1. Yellow: FS 595, No. 13538, latest issue.
2. White: No darker or yellower than FS 595, No. 17778, latest issue, when the material is placed in a type EH weatherometer for a period of 500 hours and weathered according to ASTM G153.
3. If not a visual match, the diffuse day color of the paint shall conform to the CIE Chromaticity coordinate limits as follows:

Paint CIE Chromaticity Coordinate Limits

	x	Y	x	y	x	y	x	y	Brightness
White	0.305	0.295	0.360	0.360	0.388	0.377	0.280	0.310	84.0 Min
Yellow	0.485	0.455	0.506	0.452	0.484	0.428	0.477	0.438	50.0 Min

4. Paint shall not discolor in sunlight and shall maintain colorfastness throughout its life, approximately two years. Color determination shall be made without beads, after a minimum of 24 hours.

J. Glass Bead Adhesion

1. Paint with glass beads shall require not less than 150 liters of sand to remove paint film and glass beads.

K. Scrub Resistance

1. Paint shall pass 300 cycles minimum when tested in accordance with ASTM D2486.

L. Drying time

1. Reflectorized line shall dry to no pick up in 120 seconds or less when applied at the ratio provided for specified glass spheres to paint (the paint at 15+ 1 mil (381 millimeters + 25 millimeters) wet film thickness equivalent to 100-115 square foot/gallon (2.45-2.82 square meters/liter) and the glass spheres at the equivalent rate of 6.0 pounds/gallon (0.72 kilograms/liter). The paint shall be applied with equipment so as to have the paint at a temperature of 130°F to 145°F (54°C to 63°C) at the spray gun.

2.3 GLASS BEADS

- A. Beads shall be transparent, clean, colorless glass, smooth and spherically shaped, free of milkiness, pits, or excessive air bubbles.
- B. Quality Assurance Control
 1. Beads shall be segregated into maximum lots of 2,500 pounds (1125 kilograms) and lot numbers shall be stamped onto each lot. Each lot shall be tested for gradation, rounds and embedment coating.
- C. Gradation - The glass spheres shall meet the following gradation requirements:

Glass sphere gradation (ConnDOT Grading “A”)

Sieve Size	% Passing
20 (850 um)	100
30 (600 um)	80-95
50 (300 um)	9-42
80 (180 um)	0-10

Glass sphere gradation (ConnDOT Grading “B”)

Sieve Size	% Retained
10 (2.0 mm)	0
12 (1.7 mm)	0-5
14 (1.4 mm)	5-20
16 (1.18 mm)	40-80
18 (1.0 mm)	10-40
20 (850 um)	0-5
Pan	0-2

- D. Roundness: Glass beads shall have a minimum of 80% rounds per screen for two highest sieve quantities and no more than 3% angular particles per screen for Grading “B”. The remaining sieve fractions shall typically be no less than 75% rounds.

- E. Refractive Index: Glass beads shall have a refractive index of 1.50 to 1.52.

2.4 TEMPORARY PLASTIC PAVEMENT MARKING TAPE

- A. Materials for this work shall be commercially available pavement marking tape, ASTM D4505.
- B. Tape shall be pre-coated with a pressure sensitive adhesive and shall be capable of being adhered to existing markings, on bituminous concrete pavement or portland cement concrete in accordance with the manufacturer's instructions without the use of heat, solvents or other additional adhesives, and shall be immediately ready for traffic use after application.
 - 1. Tape shall be reflective with the use of glass beads throughout the pigments.
 - 2. Tape shall be durable, flexible, formable and following application shall remain in contact with the pavement surface.
- C. Adhesion: Tape shall adhere to the pavement and existing pavement markings under climatic and traffic conditions normally encountered in the construction work zone. The tape shall be reinforced by a nonmetallic medium and pre-coated with a pressure sensitive adhesive.
- D. Removability: Tape shall be removable after its intended use, intact or in large pieces, manually, at temperatures above 40°F without the use of heat, solvents, grinding or sand or water blasting. The black line mask pavement marking tape shall be totally removed from existing markings that are adequately adhered to the pavement surface, without damage to the underlying markings.
- E. Tape shall be readily visible during daylight and when viewed with vehicular headlights at night.

2.5 PREFORMED BLACK LINE MASK PAVEMENT MARKING TAPE

- A. General
 - 1. Tape shall consist of a matte black, non-reflective tape in widths or sizes sufficiently large to mask the existing markings which are to be temporarily covered.
 - 2. Patterned masking tape shall be pre-coated with a pressure sensitive adhesive and shall be capable of being adhered to existing markings, on bituminous concrete pavement or portland cement concrete in accordance with the manufacturer's instructions without the use of heat, solvents or other additional adhesives, and shall be immediately ready for traffic use after application.
- B. Composition: The non-reflective, patterned black line mask pavement marking tape shall not contain metallic foil and shall consist of a mixture of high quality polymeric materials, pigments and inorganic fillers distributed throughout its base cross-sectional area, with a matte black non-reflective top layer. The patterned surface shall have a minimum of 20% of the surface area raised and coated with non-skid particles. The channels between the raised areas shall be substantially free of particles. The film shall be pre-coated with a pressure sensitive adhesive. A non-metallic medium shall be incorporated to facilitate removal.
- C. Skid Resistance: The surface of the patterned, nonreflective black line mask pavement marking tape shall provide an initial average skid resistance value of 60 BPN when tested in accordance with ASTM E 303.

- D. Thickness
 - 1. Patterned material, without adhesive, shall have a minimum thickness of 0.065 inch at the thickest portion of the patterned cross-section and a minimum thickness of 0.02 inch at the thinnest portion of the cross-section.
- E. Adhesion: Tape shall adhere to the pavement and existing pavement markings under climatic and traffic conditions normally encountered in the construction work zone.
- F. Removability: Tape shall be removable after its intended use, intact or in large pieces, manually, at temperatures above 40°F without the use of heat, solvents, grinding or sand or water blasting. The black line mask pavement marking tape shall be totally removed from existing markings that are adequately adhered to the pavement surface, without damage to the underlying markings.

PART 3 EXECUTION

3.1 GENERAL

- A. Pavement markings shall be applied in accordance with the details shown on the plans and the control points established by the Contractor and approved by the Engineer.
- B. No paint shall be applied to new bituminous pavement until the top course has cured at least one week minimum.
- C. Pavement areas to be painted shall be dry and sufficiently cleaned of sand and road debris so as to provide an acceptable bond between the paint and the pavement.
- D. All painting shall be performed in a neat and workmanlike manner. The lines shall be sharp and clear with no feathered edging or fogging and precautions shall be taken to prevent tracking by tires of the striping equipment. Paint shall be applied as shown on the Drawings with no unsightly deviations.
- E. Contractor shall protect the buildings, walks, pavement, curbing, trees, shrubs, mulch, etc. from over-spray of paint and damage by his operations.
- F. Operations shall be conducted only when the road surface temperature is at least 40°F or as allowed by Engineer. They shall be discontinued during periods of rain, and shall not continue until Engineer determines that the pavement surface is dry enough to achieve adhesion.
- G. After application, paint shall be protected from crossing vehicles using traffic cones or other acceptable method for a time at least equivalent to the drying or curing time of the paint.
- H. The material shall be applied to the pavement by equipment used specifically for the application of pavement markings and shall be of a standard commercial manufacturer.
- I. Contractor shall provide survey control for layout of pavement markings by utilizing his own surveyor or hiring a registered land surveyor. The cost of this survey control shall be included in other items of work.

3.2 WATERBORNE PAVEMENT MARKINGS

- A. Painted legend, arrows, and markings includes paint installed with a hand striping machine such as: stop bars, crosswalks, parking stalls, lane arrows, legends, markings within gore areas, and painting of paved islands or medians.

- B. Painted pavement markings and hot applied painted pavement markings include paint installed with a truck-mounted painting machine such as center lines, lane lines and shoulder lines.
- C. Waterborne Paint, Ambient Temperature
 - 1. Apply paint at a rate of 100 to 115 square feet per gallon, with glass beads applied at a rate of 6 pounds per gallon of paint for painted pavement markings and painted legend, arrows, and markings
- D. Waterborne Paint, Hot-Applied
 - 1. Hot-applied paint shall be applied at a temperature of 130°F to 145°F at the spray gun.
 - 2. Apply paint at a rate of 8 pounds per gallon of paint for hot-applied painted pavement markings.

3.3 TEMPORARY PLASTIC PAVEMENT MARKING TAPE

- A. Contractor will pre-mark the pavement prior to application of the marking and use a string line if required to produce a neat appearing line.
- B. Install temporary plastic pavement marking tape in accordance with manufacturer's procedures.
- C. Promptly replace marking tape which has become dislodged, torn or otherwise damaged.

3.4 PAVEMENT MARKING REMOVAL

- A. Pavement markings shall be removed before any change is made in the traffic pattern.
- B. Pavement markings shall be removed from the pavement by any method that does not materially damage the surface or texture of the pavement. Any damage to the pavement surface caused by pavement marking removal shall be repaired by Contractor at its expense by methods acceptable to Engineer.
 - 1. Removal of temporary plastic pavement marking tape shall be accomplished without the use of heat, solvents, grinding or sandblasting and in such a manner that no damage to the pavement results.
- C. Sand or other material deposited on the pavement as a result of removing pavement markings shall be removed as the work progresses. Accumulations of sand or other material which might interfere with drainage or might constitute a hazard to traffic will not be permitted.
- D. Where blast cleaning is used for the removal of pavement markings and such removal operation is being performed within 10 feet of a lane occupied by traffic, the residue including dust shall be removed immediately after contact between the sand and the surface being treated. Such removal shall be by a vacuum attachment operating concurrently with the blast cleaning operation, or by other methods approved by Engineer.

END OF SECTION

SECTION 32 1823 - INFIELD MIX

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Furnishing and installing manufactured clay based mixture on baseball/softball field infield areas.
- B. Contractor shall coordinate work between all Contractors, sections, and trades required for the proper completion of the work.
- C. Contractor shall be responsible for the health and safety of all Contractor and Subcontractor workers during progress of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.

1.3 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- A. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils.
- B. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- C. ASTM F1936 – Standard Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field.
- D. ASTM F2107 – Standard Guide for Construction and Maintenance of Skinned Areas on Baseball and Softball Fields.
- E. ASTM F2270 – Standard Guide for Construction and Maintenance of Warning Track Areas on Sport Fields.
- F. ASTM F1632 - Standard Test Method for Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Rootzone Mixes

1.4 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of the infield.
- B. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing infield mix.

1.5 SUBMITTALS

- A. Gradation: Gradation analysis of infield mix proposed for use at the Project Site, ASTM D422.

- B. Sample: 20-pound sample of infield mix proposed for use at the Project Site in an air-tight container. Such sample shall be submitted a minimum of one week prior to delivery of material to the site. Use of proposed materials by Contractor prior to approval or rejection shall be at Contractor's risk.

1.6 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

1.7 PROJECT/SITE CONDITIONS

- A. Weather Limitations: Proceed with installation of materials only when existing and forecasted weather conditions permit.
- B. Coordinate with all other trades, especially underground utility contractors, in order to prevent covering up unfinished or uninspected work and loss of time or labor by improper scheduling. Any rework shall be done at no cost to Owner.

PART 2 PRODUCTS

2.1 INFIELD MIX

- A. Infield mixture shall be the “Native Infield Mix-Light Brown Blend” that is a combination of New England clays and sands.
- B. Infield Mix shall be comprised of the following:

Mechanical Analysis of Infield Mix

Sand	70%-80%
Silt (.002 mm - .05 mm)	2-8%
Clay (less than .002 mm)	16%-25%

Grain Size Distribution of Infield Mix

Sieve	Percent Passing by Weight
1/4"	100
No. 4	98-100
No. 10	90-98
No. 18	70-85
No. 35	40-60
No. 60	10-20
No. 100	3-7
No. 140	0-4

Notes:

- 1) 0% greater than 1/4-inch sieve.
- 2) Maximum of 30% greater than No. 18.
- 3) Minimum of 50% between No. 18 and No. 60.
- 4) Maximum of 20% smaller than No. 60.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Furnish and construct infield mix to the lines and grade shown on the Drawings.
- B. In advance of installing infield mix, remove all existing materials and install sand base as indicated on the Drawings.
- C. Install infield mix such that the edges of the infield meet the grades of adjacent turf areas. Ensure no ridges or depressions at the edges.
- D. Compact the materials with a roller to keep a smooth and level surface. Achieve optimum moisture content by adding water during application. Do not over-water.
- E. Nail drag, rake, or screen drag the infield until the top 1/4-inch to 1/2-half inch of the surface is loose.
- F. Re-level infield and verify grades.
- G. Apply final top-dressing of 1/4-inch of infield mix. Rake to smooth, even finish.

3.2 CLEANUP AND PROTECTION

- A. During installation, keep adjacent areas clean and work area in an orderly condition.
- B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Repair any damage.

END OF SECTION

SECTION 32 3113

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes
 - 1. Furnishing and installing woven wire fencing of the type and height specified and supported by metal posts erected where indicated on the Drawings and as specified herein.
 - 2. Furnishing and installing woven wire fencing gates of the type and height specified and supported by metal posts erected where indicated on the Drawings and as specified herein.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM).
 - 1. ASTM A90- Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc Alloy.
 - 2. ASTM A123- Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
 - 3. ASTM A153- Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
 - 4. ASTM A392- Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
 - 5. ASTM A428- Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles.
 - 6. ASTM A491- Standard Specification for Aluminum Coated Steel Chain Link Fence Fabric.
 - 7. ASTM A817- Standard Specification for Metallic-Coated Steel Wire for Chain Link Fence Fabric and Marcellled Tension Wire.

8. ASTM A824- Standard Specification Metallic-Coated Steel Marcellled Tension Wire for Use with Chain Link Fence.
 9. ASTM B211- Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod and Wire.
 10. ASTM C94- Standard Specification for Ready-Mixed Concrete.
 11. ASTM F567- Standard Practice for Installation of Chain Link Fence.
 12. ASTM F626- Standard Specification for Fence Fittings.
 13. ASTM F900- Standard Specification for Industrial and Commercial Swing Gates.
 14. ASTM F1043- Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
 15. ASTM F1083- Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
 16. ASTM F1183- Standard Specification for Aluminum Alloy Chain Link Fence Fabric.
- D. Chain Link Fence Manufacturer's Institute
1. Chain Link Fence Manufacturer's Institute Product Manual, latest revision.

1.3 SYSTEM DESCRIPTION

- A. Temporary Construction Fence shall meet the following basic parameters:
1. Fence Height: 8 feet.
 2. Mesh Size: 2 inches.
 3. Mesh Gage: 12
 4. Gates: Height of gates shall match that of fence. Width of gates shall be as shown on the Drawings.
 5. Anchored post or driven posts where indicated. No top or bottom rails required.
 6. Panelized/modular units where indicated. Two stabilizers per panel.
- B. Permanent Fence shall meet the following basic parameters:
1. Fence Height: Varies, refer to Drawings for fence heights
 2. Mesh Size: 2 inches.
 3. Mesh Gage: Wire with a diameter of 9 gauge galvanized core fused. Measured prior to application of coating.
 4. Gates: Height of gates shall match that of fence. Type and size of gates shall be as shown on the Drawings.

5. Anchored post where indicated; top and bottom rails between posts.

1.4 SUBMITTALS

- A. Shop drawings showing the plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates and a schedule of components.
- B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
 1. Fence and gate posts, rails, and fittings.
 2. Chain-link fabric, reinforcements, and attachments.
 3. Accessories: Privacy slats.
 4. Gates, locking mechanisms and hardware.
 5. Gate operators, including operating instructions.
 6. Motors (if applicable): Show nameplate data, ratings, characteristics, and mounting arrangements.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
 1. Gate Operator (if applicable): Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
 2. Wiring Diagrams (if applicable): For power, signal, and control wiring.
- D. Samples for Initial Selection: For components with factory-applied color finishes.
- E. Samples for Verification: Prepared on Samples of size indicated below:
 1. Polymer-Coated Components: In 6-inch lengths for components and on full-sized units for accessories.
- F. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified factory-authorized service representative.
- B. Product Certificates: For each type of chain-link fence, and gate, from manufacturer.
- C. Product Test Reports: For framing strength according to ASTM F 1043.
- D. Field quality-control reports.
- E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
 - 1. Polymer finishes.
 - 2. Gate hardware.
 - 3. Gate operator.

1.7 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Supply material in accordance with Chain Link Fence Manufacturer's Institute Product Manual and this Specification.
- C. Perform installation in accordance with ASTM F567.
- D. Maintain all facilities installed under this Section in proper and safe condition throughout the progress of the work.
- E. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- F. 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.
- G. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.
- H. Mockups: Build mockups to set quality standards for fabrication and installation.
 - 1. Include 10-foot length of fence and gate.
- I. Preinstallation Conference: Conduct conference at Project site.
 - 1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
 - 2. Review sequence of operation for each type of gate operator.
 - 3. Review coordination of interlocked equipment specified in this Section and elsewhere.
 - 4. Review required testing, inspecting, and certifying procedures.

1.8 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Deliver fence fabric and accessories in packed cartons or firmly tied rolls.

- B. Packages shall be labeled with the manufacturer's name.
- C. Store fence fabric and accessories in a secure and dry place.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of gate operators and controls.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
- B. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 GENERAL

- A. Material furnished shall be in good condition and shall not have been painted.
- B. All posts and rails shall be straight, true to section and of sufficient length for proper installation.
- C. Unless otherwise specified, hardware and accessories shall conform to the requirements of ASTM F626 and ASTM A123 or ASTM A153 as applicable for zinc-coating.

2.2 LINE POSTS

- A. Type I: 2-inch nominal (2.375 O.D.) steel pipe, 3.65 pounds per linear foot (lb/lf), hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 ounces per square foot (oz/ft²) interior/exterior conforming to ASTM F1043.
- B. Type II: 2-inch nominal (2.375 O.D.) steel pipe, 3.12 lb/lf, cold formed and welded per ASTM F1043, Group IC, minimal yield Strength 50,000 pounds per square inch (psi). External zinc coating shall be Type B, zinc with polymer film, 0.90 oz/ft². Internal coating shall be Type B, zinc 0.90 oz/ft² minimum, or type D, zinc pigmented, 81% nominal coating with 0.30 mils minimum thickness.

2.3 CORNER, END, AND PULL POSTS

- A. Type I: 2.5-inch nominal (2.875 O.D.) steel pipe, 5.79 pounds lb/lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz/ft² interior/exterior conforming to ASTM F1043.
- B. Type II: 2.5-inch nominal (2.875 O.D.) steel pipe, 4.64 lb/lf. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz/ft². Internal coating shall be Type B, zinc 0.90 oz/ft² minimum, or type D, zinc pigmented, 81% nominal coating with 0.30 mils minim thickness.

2.4 BRACE ASSEMBLY

A. Rails

1. Type I: 1.25-inch nominal (1.660 O.D.) steel pipe, 2.27 lb/lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz/ft² interior/exterior conforming to ASTM F1043.
2. Type II: 1.25-inch nominal (1.660 O.D.) steel pipe, 1.83 lb/lf. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz/ft². Internal coating shall be Type B, zinc 0.90 oz/ft² minimum, or type D, zinc pigmented, 81% nominal coating with 0.30 mils minim thickness.

B. Truss rod shall be 3/8-inch zinc-coated steel with adjustable turnbuckles or truss tightener.

2.5 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI Product Manual and with requirements indicated below:

1. Fabric Height: As indicated on Drawings.
2. Steel Wire Fabric: Wire with a diameter of 9 gauge galvanized core fused. Measured prior to application of coating.
 - a. Mesh Size: 2 inches. Measured prior to application of coating.
 - b. Polymer-Coated Fabric: ASTM F 668, Class 2b.
 - 1) Color: Black, complying with ASTM F 934.
 - c. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
3. Selvage: Knuckled at both selvages.

2.6 FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 based on the following:

1. Fence Height: As indicated on Drawings.
2. Light Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe.
 - a. Line Post: 4' and under Fencing: 1-7/8" OD Pipe (Sch 40), 6' Fencing: 2-3/8" OD Pipe (Sch 40) and 12' Fencing: 3" OD Pipe (Sch 40).
 - b. End, Corner and Pull Post: 4' and under Fencing: 2-1/2" OD Pipe (Sch 40), 6' Fencing: 2-7/8" OD Pipe (Sch 40), 12' Fencing: 3" OD Pipe (Sch 40).
3. Horizontal Framework Members: Intermediate top and bottom rails complying with ASTM F 1043.
 - a. Top, Bottom and Mid Rail for all fencing systems and all heights: 1 5/8" OD Pipe (Sch 40). 5' Maximum spacing between center rails.

b. Brace Rails: Comply with ASTM F 1043.

B. Metallic Coating for Steel Framing:

1. Type A, consisting of not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating per ASTM A 123/A 123M or 4.0-oz./sq. ft. (1.22-kg/sq. m) zinc coating per ASTM A 653/A 653M.
2. Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
3. External, Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil- (0.0076-mm-) thick, zinc-pigmented coating.
4. Type C, Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. (0.55-kg/sq. m) coating.
5. Coatings: Any coating above.

C. Polymer coating over metallic coating.

D. Color: Black, complying with ASTM F 934.

2.7 STRETCHER BARS

- A. Bars shall be one piece lengths of zinc-coated steel, not less than 2-inches shorter than the full height of the fencing fabric with a minimum cross section of 3/16-inch by 3/4-inch in accordance with ASTM F626.
- B. Polymer coating over metallic coating.
- C. Color: Black, complying with ASTM F 934.

2.8 TENSION WIRE

- A. Polymer-Coated Steel Wire: Marcellled (spiraled or crimped) No. 7 gage, (0.177-inches) diameter, ASTM A824, ASTM F 1664, Class 2b over-coated steel wire.
- B. Polymer coating over metallic coating.
- C. Color: Black, complying with ASTM F 934.

2.9 HARDWARE AND TIES

- A. Miscellaneous hardware, including but not limited to nuts, bolts, washers, clips, bands, rail ends, brackets, and straps shall be provided as required, hot-dip galvanized steel or aluminum alloy, ASTM F626.
- B. Tension bands shall be formed from flat or beveled steel and shall have a minimum thickness after galvanizing of 0.078-inches and a minimum width of 3/4-inch.
- C. Brace bands shall be formed from flat or beveled steel and shall have a minimum thickness after galvanizing of 0.108-inches and a minimum width of 3/4-inch.

- D. Wire ties shall be minimum 16-gage galvanized steel wire or minimum 9-gage aluminum alloy wire.
- E. All fasteners shall be hot-dip galvanized, ASTM F2329.
- F. Bolts: Steel, ASTM A307.
- G. Washers: Steel, round, ASTM F844.
- H. Bolts: Steel, ASTM A563 Grade A, hex head.

2.10 FITTINGS

- A. General: Comply with ASTM F 626.
- B. Post Caps: Provide for each post.
 - 1. Provide line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
 - 1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.
 - 2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails in the fence line-to-line posts.
- E. Tension and Brace Bands: Pressed steel.
- F. Tension Bars: Steel, length not less than 2 inches (50 mm) shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
 - 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
 - a. Hot-Dip Galvanized Steel: 0.148-inch- (3.76-mm-) diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.
- I. Finish:
 - 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g /sq. m) zinc.
 - a. Polymer coating over metallic coating.

2.11 MODULAR OR PANELIZED FENCE

- A. Free-standing fence panels, minimum ten (10) foot panels of the height specified.
- B. Fabric as specified.
- C. Welded tubular steel frame.

- D. Stands: Four sided welded tubular steel frame with center bar and tubular sleeves.

2.12 GATES

- A. Gate Construction: ASTM F900. Corners welded or assembled with special malleable or pressed-steel fittings and rivets or bolts to provide rigid connections.
- B. Pipe and Tubing:
 - 1. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing.
- C. Posts: Round tubular steel.
 - 1. 4' Fencing: 2 7/8" OD Pipe (Sch 40)
 - 2. 6' and 10' Fencing: 4" OD Pipe (Sch 40)
- D. Gate Frames and Bracing: Round tubular steel.
 - 1. Framing:
 - a. 2" OD Pipe (Sch 40) Welded
 - b. Assemble gate frames by welded connections. When width of gate leaf exceeds 10 feet, install mid-distance vertical tubing of the same size and weight as frame members. When either horizontal or vertical bracing is not required, provide truss rods as cross bracing to prevent sag or twist.
 - c. Horizontal bid bracing shall be used on all gates.
- E. Wire Fencing Fabric: Fabric shall match that of fence, attached securely to frame at intervals not exceeding 15-inches.
- F. Hardware:
 - 1. Hinges: 360-degree inward and outward swing.
 - 2. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
 - 3. All gates shall be equipped with hot-dipped galvanized steel hinges and latch with provisions for padlocking.
 - 4. Double gates and single gates with leaf width 4 feet and greater shall be equipped with a minimum 1/2" drop bar and gate hold backs.
 - 5. Hinges shall be cast steel hinges capable of 360 degree opening. Set screw shall be installed drilled into the steel post to lock each hinge to the gate post and prevent rotation. No-lift-off type. Box type hinges are not acceptable.
 - 6. Gate Leaves: Configured with intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist.
 - 7. Latches, hinges, stops, keepers and other hardware items shall be furnished as required for proper operation.

2.13 PRIVACY SLATS (IF APPLICABLE)

- A. Material: PVC, UV-light stabilized, flame resistant, four ply, not less than 0.023 inch (0.58 mm) thick; sized to fit mesh specified for direction indicated.
- B. Material: Redwood, 5/16 inch (7.9 mm) thick, sized to fit mesh specified for direction indicated.
- C. Color: As selected by Architect from manufacturer's full range.

2.14 CONCRETE

- A. Concrete shall conform to ASTM C94; or pre-packaged concrete mix, ASTM C 387. Minimum 28-day compressive strength of 3000 psi.

2.15 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

PART 3 EXECUTION

3.1 GENERAL

- A. Install fence with properly trained crew as shown on the drawings in accordance with ASTM F567.
- B. Install all nuts for tension bands and hardware bolts on the side of the fence opposite the fabric.
- C. The temporary chain link fence shall be removed at the conclusion of the work.

3.2 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 - 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.4 INSTALLATION, GENERAL

- A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
 - 1. Install fencing on established boundary lines inside property line.

3.5 CHAIN-LINK FENCE INSTALLATION

- A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete post footings shall have a plan diameter 12-inches greater than the post diameter. Holes shall be clean and free of loose soil and debris. Concrete shall be placed continuously in one operation and tamped or vibrated for consolidation. Tops of the concrete footings shall be crowned to shed water.
 - 3. Gate post/footings shall be installed a minimum of 42-inches below grade.
 - 4. All corner, end posts, and gate posts shall be braced.
 - a. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail one bay from end and gate posts.
 - b. Corner and terminal posts are to be braced horizontally and diagonally. The braces are to extend over one adjacent panel. Changes in line of 30 degrees or more shall be considered as corners.
 - c. Braces and truss rods shall be securely fastened to posts with appropriate hardware.
 - d. Pull posts with two braces shall be provided for all heights where changes in horizontal or vertical alignment of ten (10) degrees or more occur.
 - 5. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Concealed Concrete: Top 3 inches below grade as indicated on Drawings to allow covering with surface material.
 - b. Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
 - c. Posts Set into Voids in Concrete: Form or core drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.

- C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.
- D. Line Posts: Space line posts uniformly at 10 feet o.c.
- E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
 - 1. horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
 - 1. Extended along top and bottom of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches (152 mm) of bottom of fabric and tie to each post with not less than same diameter and type of wire.
- G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- H. Intermediate and Bottom Rails: Install and secure to posts with fittings.
- I. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 1 inch between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.
- K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches o.c.
- L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.
- M. Privacy Slats: Install slats in direction indicated, securely locked in place.
 - 1. Diagonally, for privacy factor of 80 to 85.
- N. Fabric:

1. Do not install fabric until concrete post footings have cured seven (7) days. Provide fabric of the height specified. Install fabric on the public side of the fence, with bottom no greater than 2-inches above the ground surface. Fabric shall be pulled taut to prevent sagging and provide a uniform smooth appearance. Fasten fabric to line posts at intervals not exceeding 15-inches with ties as specified.
2. Install tension wire in one continuous length between pull posts, weaved through fence fabric at top. Tension wire shall be applied to provide a wire without visible sag between posts. Fasten fabric to tension wire at intervals not exceeding 24-inches with ties or hog rings as specified.
3. Where it is not practicable to conform the fence to general contour of the ground, as at ditches, channels, etc., the opening beneath the fence shall be enclosed with chain link fabric and sufficiently braced to preclude access, but not to restrict the flow of water.

3.6 GATE INSTALLATION

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.
- B. Provide swing gates at the locations and dimensions shown on the Drawings. Do not install gates until concrete post footings have cured seven (7) days.
- C. Gates shall be installed plumb, level, and secure, with full opening without interference. Hardware shall be installed and adjusted for smooth operation and lubricated where necessary.
- D. Provide concrete center drop to footing depth and suitable drop rod sleeve at center of double gate openings.

3.7 GATE OPERATOR INSTALLATION (IF APPLICABLE)

- A. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
- B. Excavation for Support Posts Pedestals Equipment Bases/Pads: Hand-excavate holes for bases/pads, in firm, undisturbed soil to dimensions and depths and at locations as required by gate-operator component manufacturer's written instructions and as indicated.

3.8 GROUNDING AND BONDING

- A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:
- B. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
 1. Gates and Other Fence Openings: Ground fence on each side of opening.
 2. Bond metal gates to gate posts.

3. Coordinate subparagraph below with Drawings in projects where intentional discontinuities are provided in metal fencing conductivity to localize lightning effects to the vicinity of strikes. See Evaluations.
 4. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.
- D. Plans and details on Electrical Drawings and requirements in Division 26 Sections may revise or illustrate application of requirement below or may require grounding that exceeds minimum requirements in IEEE C2. Fences enclosing electrical substations are often bonded to a station grounding mat.
- E. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
- F. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:
1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
 2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
- G. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- H. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- I. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.9 FIELD QUALITY CONTROL

- A. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
 - 1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
 - 2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
 - 3. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.10 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Lubricate hardware and other moving parts.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION

SECTION 32 3119 - ORNAMENTAL FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes
 - 1. Furnishing and installing decorative metal fencing of the style, and at the locations, indicated on the Drawings.
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM).
 - 1. ASTM A36 - Structural Steel.
 - 2. ASTM A90- Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc Alloy.
 - 3. ASTM A123- Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A153- Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
 - 5. ASTM A385- Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
 - 6. ASTM A428- Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles.
 - 7. ASTM A500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 - 8. ASTM C94- Standard Specification for Ready-Mixed Concrete.
 - 9. ASTM D822 - Tests on Paint and Related Coatings Using Filtered Open-Flame Carbon-Arc Exposure Apparatus.
 - 10. ASTM D1794 - Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
 - 11. ASTM D3363 - Test Method for Film Hardness by Pencil Test.

12. ASTM F1083- Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
13. ASTM F2408- Standard Specification for Ornamental Fences Employing Galvanized Steel Tubular Pickets.

1.3 SUBMITTALS

- A. Shop drawings showing the plan layout and spacing of brackets, rails, posts and other components, post foundation dimensions, hardware anchorage, gates, and a schedule of such components. Show in large-scale details any unique fabrications and setting requirements.
- B. Material certificates or other data indicating compliance with these Specifications for color, posts, fittings, hardware, and accessories.
- C. Manufacturer's warranty.

1.4 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver fencing and accessories in packed cartons or other protective packaging.
- B. Store materials to avoid damage from moisture, abrasion, and other construction activities.

1.6 SAMPLE PANELS

- A. Contractor shall construct and/or fabricate samples for the following item in accordance with approved Shop Drawings and manufacturer's product literature:
 - B. Fence panel Section: minimum five-(5) foot length. All items shall be complete in place. The quality of workmanship must be approved by Landscape Architect before permanent construction is started. If the original sample is not approved, the Contractor shall provide additional samples as required, at no cost to the Owner, until an approved sample is obtained. The approved sample shall become the standard for the entire job. The samples can be constructed at a location that will become part of the work.
 1. Obtain Engineer's written acceptance of samples before proceeding with the final work.

1.7 WARRANTY

- A. Provide 10 year manufacturer's warranty for factory finish against cracking, peeling, and blistering under normal use.

PART 2 PRODUCTS

2.1 GENERAL

- A. Provide ornamental fence as indicated on the Drawings.

- B. Material of Construction: Steel.
 - 1. Bar Stock: ASTM A36.
 - 2. Steel tubing: ASTM A500, Grade B.
 - 3. Fasteners: Stainless steel, color to match fence.
- C. Finish Coating: Polyester powder coating, satin black.
 - 1. Polyester powder coating: Electrostatically applied colored polyester powder coating heat cured to chemically bond finish to metal substrate.
 - a. Minimum hardness measured in accordance with ASTM D3363: 2H.
 - b. Direct impact resistance tested in accordance with ASTM D2794: Withstand 160 inch-pounds.
 - c. Salt spray resistance tested in accordance with ASTM B117: No undercutting, rusting, or blistering after 500 hours in 5 percent salt spray at 95 degrees F and 95 percent relative humidity and after 1000 hours less than [3/16 inch] [5 mm] undercutting.
 - d. Weatherability tested in accordance with ASTM D822: No film failure and 88 percent gloss retention after 1 year exposure in South Florida with test panels tilted at 45 degrees.
- D. Concrete
 - 1. Ready-mix ASTM C-94 with maximum size of 1-inch. Minimum 28-day compressive strength of 4,000 psi.
 - 2. Pre-packaged concrete mix with maximum aggregate size of 1-inch, ASTM C 387. Minimum 28-day compressive strength of 4,000 psi.

PART 3 EXECUTION

3.1 GENERAL

- A. Fabricate and install all fencing as indicated on the Drawings and in conformance with approved Shop Drawings.
- B. Install fencing with accessories furnished by the manufacturer as required for a complete and finished installation. All elements shall be installed to produce a uniform continuous fence.
- C. Install gates at the locations indicated. Verify all swing directions prior to installation. Perform function test for each gate to ensure proper operation of all components.

END OF SECTION

SECTION 32 3300 - BOLLARDS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Installation of traffic control bollards
- B. Contractor shall coordinate work between all Subcontractors, sections, and trades required for the proper completion of the work.

1.2 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. United States Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM)
 - 1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated and Welded and Seamless.
 - 2. ASTM A366 - Standard Specification for Steel, Carbon, Cold-Rolled Sheet, Commercial Quality.
 - 3. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Tubing in Rounds and Shapes.
 - 4. ASTM D1640 - Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature.
 - 5. ASTM D5893 - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
- D. United States General Services Administration, Federal Standards.
 - 1. Federal Standard No. 595 - Colors Used in Government Procurement.

1.3 PERFORMANCE REQUIREMENTS

- A. Bollard installs as a single unit with specified dimensions and is secured in the ground.

1.4 SUBMITTALS

- A. Submit Shop Drawings, manufacturer's literature, material certificates or other data indicating compliance with these Specifications.
- B. Submit testing data for concrete as required by Section 03 3200 - Site Cast-in-Place Concrete.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Supply: Bollard units of all types must be supplied by a single manufacturer having the resources to provide consistent quality in appearance and physical properties.
- B. Materials shall be wrapped for shipment and storage, delivered to the jobsite in manufacturer's original packaging.
- C. Store units to avoid damage from moisture, abrasion, and other construction activities.

PART 2 PRODUCTS

2.1 STEEL BOLLARDS

- A. New single bit cast steel tube as shown on the Drawings, free from surface blemishes and defects where exposed to view in the finished installation.
- B. Steel Tube: ASTM A53/A53M, four (4) inch diameter, length as indicated on the Drawings.
- C. Painting and Cleaning: After fabrication of units, all tool marks and surface imperfections shall be removed and exposed faces of all welded joints dressed smooth. Coat with a standard rust-inhibitive primer.
- D. Primed (Standard): Apply standard rust inhibitive primer per manufacturer standard application instructions.

2.2 CONCRETE

- A. Concrete shall be as specified in Section 033200 - Site-Cast-in-Place Concrete.

2.3 PRIMER

- A. Waterborne primer, acrylic or modified acrylic, suitable for use on exterior metal surfaces.
- B. Drying time. The dry-to-touch time shall be a maximum of one hour, and the dry-to-recoat time shall be a maximum of 4 hours when tested in accordance with ASTM D 1640.

2.4 PAINT

- A. Waterborne paint, acrylic or modified acrylic, suitable for use on exterior metal surfaces
- B. Color: FS 13591 (yellow).
- C. Drying time. The dry-to-touch time shall be a maximum of one hour, and the dry-to-recoat time shall be a maximum of 4 hours when tested in accordance with ASTM D 1640.

2.5 JOINT FILLER

- A. One-part, cold-applied silicone that cures to a durable, flexible, low modulus silicone rubber joint seal, ASTM D5893.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install bollards at the locations indicated on the Drawings.
- B. Install bollards level and true to the specific depths and exposures as indicated on the Drawings.
- C. Provide temporary bracing as required to maintain desired installation until concrete has cured.
- D. Protect newly-installed bollards from damage or movement.

3.2 PAINTING

- A. Primer: If not factory primed, apply primer in accordance with manufacturer's guidelines. Apply primer at temperatures between 50 °F and 100 °F and a relative humidity no higher than 85 percent.
- B. Paint: Apply paint of the color selected in accordance with manufacturer's guidelines. Apply paint at temperatures between 50 °F and 100 °F and a relative humidity no higher than 85 percent. Protect freshly-painted surfaces from damage.

END OF SECTION

SECTION 32 9000

PLANTING

SECTION 329300 - PLANTS

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. Includes:

- 1. Plants.
- 2. Planting soils.
- 3. Tree stabilization.

B. Related Sections:

- 1. Division 01 Section "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
- 2. Division 12 Section "Site Furnishings" for exterior unit planters.
- 3. Division 31 Section "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
- 4. Division 31 Section "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
- 5. Division 32 Section "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
- 6. Division 33 Section "Subdrainage" for below-grade drainage of landscaped areas, paved areas, and wall perimeters.

1.3 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

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- C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.
 - D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.
 - E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
 - F. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
 - G. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
 - H. Finish Grade: Elevation of finished surface of planting soil.
 - I. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
 - J. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
 - K. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
 - L. Planting Area: Areas to be planted.
 - M. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
 - N. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
 - O. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
 - P. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

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- Q. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
 - R. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
 - S. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, including soils.
 - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
 - 2. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to the Project.
 - a. Contractor shall follow all Connecticut DEEP regulations for pesticide and herbicide applications.
 - 3. Plant Photographs: Include color photographs in 3- by 5-inch print format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
- B. Samples for Verification: For each of the following:
 - 1. Trees and Shrubs: Three samples of each variety and size delivered to the site for review. Maintain approved samples on-site as a standard for comparison.
 - 2. Organic Mulch: 1-pint volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
 - 3. Mineral Mulch: 2 lb of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.
 - 4. Weed Control Barrier: 12 by 12 inches.
 - 5. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.

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- C. **Qualification Data:** For qualified landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
 - D. **Product Certificates:** For each type of manufactured product, from manufacturer, and complying with the following:
 - 1. Manufacturer's certified analysis of standard products.
 - 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
 - E. **Material Test Reports:** For standardized ASTM D 5268 topsoil existing native surface topsoil existing in-place surface soil and imported or manufactured topsoil.
 - F. **Maintenance Instructions:** Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before start of required maintenance periods.
 - G. **Warranty:** Sample of special warranty.

1.5 QUALITY ASSURANCE

- A. **Installer Qualifications:** A qualified landscape Installer whose work has resulted in successful establishment of plants.
 - 1. **Professional Membership:** Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. **Experience:** Five years' experience in landscape installation in addition to requirements in Division 01 Section "Quality Requirements."
 - 3. **Installer's Field Supervision:** Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. **Personnel Certifications:** Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation maintenance specialty area(s), designated CLT-Exterior.
 - b. Certified Landscape Technician - Interior, designated CLT-Interior.
 - c. Certified Ornamental Landscape Professional, designated COLP.
 - 5. **Pesticide Applicator:** State licensed, commercial.
- B. **Soil-Testing Laboratory Qualifications:** An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

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- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for plant growth.
 - a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
- D. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
1. Selection of plants purchased under allowances will be made by Architect, who will tag plants at their place of growth before they are prepared for transplanting.
- E. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- F. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials seven days in advance of delivery to site.

G. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

C. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.

4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
 1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of each service or utility.
 2. Do not proceed with interruption of services or utilities without Construction Manager's written permission.
- C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 1. Spring Planting: March 15 to May 15.
 2. Fall Planting: September 1 to November 15.
- D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.8 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.

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- c. Faulty performance of tree stabilization.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Periods from Date of Substantial Completion:
 - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
 - b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
 - c. Annuals: Three months.
 3. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.
 - d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until substantial completion but for not less than maintenance period below if substantial complete comes earlier.
 1. Maintenance Period: Three months from date of planting completion.
- B. Initial Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until substantial completion but for not less than maintenance period below if substantial completion comes earlier.
 1. Maintenance Period: Three months from date of planting completion.
- C. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 PRODUCTS

2.1 PLANT MATERIAL

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- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Labeling: Label at least one plant of each variety, size, and caliper in each planting bed with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.
- E. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- F. Annuals: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

2.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
 2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
 3. Provide lime in form of ground dolomitic limestone or calcitic limestone depending on recommendations from soil analysis.

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- B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
 - C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
 - D. Aluminum Sulfate: Commercial grade, unadulterated.
 - E. Perlite: Horticultural perlite, soil amendment grade.
 - F. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.
 - G. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
 - H. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
 - I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.3 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.
- C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
 - 1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.
- E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- E. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
 - 1. Size: 5-gram tablets.
 - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.
- F. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

2.5 PLANTING SOILS

- A. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth. Mix ASTM D 5268 topsoil with the soil amendments and fertilizers as recommended by the soil analysis to produce planting soil.

2.6 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Aged double-shredded bark.
2. Size Range: 2 inches maximum, 1/2 inch minimum.
3. Color: Natural.

2.7 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally-encountered chemicals, alkalis, and acids.
- B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd..
- C. To be installed in all planting beds and in tree rings between soil and mulch.

2.8 PESTICIDES

- A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.9 TREE STABILIZATION MATERIALS

- A. Stakes and Guys:
 1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood or softwood with specified wood pressure-preservative treatment, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
 2. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.
 3. Flexible Ties: Wide rubber of length required to reach stakes or turnbuckles.
 4. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
 5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.

6. Guy Cables: Five-strand, 3/16-inch- diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8-inch galvanized eyebolts.
7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

2.10 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWPA C2, with waterborne preservative for soil and freshwater use, acceptable to authorities having jurisdiction, and containing no arsenic; including ammoniacal copper arsenate, ammoniacal copper zinc arsenate, and chromated copper arsenate.
- 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 written instructions.
- C. Burlap: Non-synthetic, biodegradable.
- D. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.
- E. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
 - 1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
- F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.3 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting areas to a minimum depth of 8 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
 - 2. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - 3. Spread planting soil to a depth of 12 inches but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top 2 inches of subgrade. Spread remainder of planting soil.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

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- D. Application of Mycorrhizal Fungi: As recommended by manufacturer.

3.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
1. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
 2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
 3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
 4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
 5. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
 6. Maintain supervision of excavations during working hours.
 7. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
 8. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.
- B. Subsoil and topsoil removed from excavations may not be used as planting soil.
- C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
1. Hardpan Layer: Drill 6-inch- diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.
- D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
- E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

- A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most

root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

- B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare flush with adjacent finish grades.
 - 1. Use planting soil for backfill.
 - 2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 - 3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 - 4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
 - 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Set container-grown stock plumb and in center of planting pit or trench with root flare flush with adjacent finish grades.
 - 1. Use planting soil for backfill.
 - 2. Carefully remove root ball from container without damaging root ball or plant.
 - 3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 - 4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
 - 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. Set and support bare-root stock in center of planting pit or trench with root flare flush with adjacent finish grade.
 - 1. Use planting soil for backfill.
 - 2. Spread roots without tangling or turning toward surface, and carefully work backfill around roots by hand. Puddle with water until backfill layers are completely saturated.

Plumb before backfilling, and maintain plumb while working backfill around roots and placing layers above roots.

3. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside soil-covered roots about 1 inch from root tips; do not place tablets in bottom of the hole or touching the roots.
 4. Continue backfilling process. Water again after placing and tamping final layer of soil.
- F. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 MECHANIZED TREE SPADE PLANTING

- A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
- B. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
- C. Cut exposed roots cleanly during transplanting operations.
- D. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.
- E. Plant trees as shown on Drawings, following procedures in "Tree, Shrub, and Vine Planting" Article.
- F. Where possible, orient the tree in the same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

- A. Install trunk stabilization as follows unless otherwise indicated:

1. Upright Staking and Tying: Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend to the dimension shown on Drawings above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
 2. Use two stakes for trees up to 12 feet high and 2-1/2 inches or less in caliper; three stakes for trees less than 14 feet high and up to 4 inches in caliper. Space stakes equally around trees.
 3. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
 4. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
- B. Staking and Guying: Stake and guy trees more than 6 feet in height and more than 2 1/2 inches in caliper unless otherwise indicated. Securely attach no fewer than three guys to stakes 30 inches long, driven to grade.
1. Site-Fabricated Staking-and-Guying Method:
 - a. For trees more than 6 inches in caliper, anchor guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle for each guy wire and tighten securely.
 - b. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - c. Support trees with strands of cable or multiple strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - d. Attach flags to each guy wire, 30 inches above finish grade.
 - e. Paint turnbuckles with luminescent white paint.
 2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.
1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.
 - a. Install stakes of length required to penetrate at least to the dimension shown on Drawings below bottom of backfilled excavation. Saw stakes off at horizontal stake.

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- b. Install screws through horizontal hold-down and penetrating at least 1 inch into stakes. Pre-drill holes if necessary to prevent splitting wood.
 - c. Install second set of stakes on other side of root trunk for larger trees as indicated.
2. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
- D. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.
1. Site-Fabricated Palm-Bracing Method:
 - a. Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact trunk.
 - b. Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.
 2. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.9 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.
- E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.10 PLANTING AREA MULCHING

- A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 24-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
 - 2. Organic Mulch in Planting Areas: Apply 3-inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.11 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.12 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.13 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.14 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION

SECTION 32 9201 – ROOT ZONE MIX FOR BALLFIELDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Under this Section, the Contractor shall furnish all labor, materials, equipment and transportation required to furnish and place Root Zone Mix for Ballfields as shown on the drawings and as specified.
- B. Prospective bidders are advised that significant quantities of topsoil are present at the property and presumably available for reuse if compatible with the requirements of this specification. The contractor shall refer to the Soil Evaluation Report and Test pit logs for the site. The Contractor shall be responsible for amending topsoil, as required to comply with this specification.
- C. This work shall consist of preparing a root zone mixture consisting of screened native on site loam, sand and compost. The root zone mix will be evaluated by using the ASTM test methods for High Predominance Sand-based Root Zones for Sports Fields, ASTM F 2396. A sand sample and compost sample shall be submitted to testing agent for adherence to specifications. This material can be either pre-blended and brought on-site or the compost and sand can be blended with soils stockpiled at the construction site.

1.2 RELATED SECTIONS

- A. Section 31 23 10 - Earthwork
- B. Section 32 92 19 - Seeding

1.3 SUBMITTALS

- A. Submit the following:
 - 1. Manufacturer's/Suppliers product data sheets, test results, specifications and installation instructions.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Do not deliver access doors to the site, until all specified submittals have been submitted to, and approved by, the Architect.
- B. Store access door units inside, under cover, and in manner to keep them dry, protected from weather, direct sunlight, surface contamination, corrosion and damage from construction traffic and other causes.

1.5 REFERENCES

- A. ASTM- American Society for Testing and Materials.

1.6 SAMPLES/TESTS

- A. The Contractor shall furnish a Certified Laboratory Report showing the soils classification and nutrient analysis of representative samples of the Loam that is proposed to be used, including the extent of lime and fertilizer required. Samples submitted for approval must be representative of the total volume to be furnished, taken in the presence of the Owners

Representative, and delivered -to a certified laboratory by the Contractor; all costs for such shall be borne by the Contractor.

- B. If the material does not conform to the above requirements it shall be rejected and additional sources shall be found. Sampling and testing shall be accomplished as specified herein until an approved material is found, all at the Contractor's expense.
- C. To assure that materials fulfill specified requirements regarding textural analysis, organic matter content, pH, and fertility testing may be undertaken:
 - 1. Prior to site delivery; at source;
 - 2. At time of delivery; on-site; and or
 - 3. Immediately following spreading on site, Soil sampling shall also indicate if specified soil was supplied uniformly to the minimum specified depth.

1.7 NOTIFICATION

- A. The Contractor shall notify the Owner in writing at least ten (10) days in advance of the time he intends furnishing Root Zone Mix stating the location and amount of such deposit, the name and address of the supplier and also shall furnish such facilities, transportation and assistance as the Owner may require for collecting and forwarding samples.

1.8 QUALITY CONTROL

- A. Root zone mix: A one gallon sample for every 2,000 cubic yards of root zone mix shall be tested by the Owner's Testing Agent for approval.
- B. The Contractor or Sub-contractor must have a minimum of five (5) years of experience installing root zone mix based athletic fields of similar size and quality of this project.

PART 2 - PRODUCTS

2.1 LOAM BORROW

- A. Refer to Section 32 92 19 – Seeding.

2.2 SAND

- A. Sand for Root Zone Mix and Sub-drainage backfill shall conform to ASTM standard F 2396 Sand for High Performance Sand-based Rootzones for Sports Fields.

2.3 ORGANIC MATERIAL

- A. Compost shall be derived from organic wastes including sawdust, clean ground wood, leaf and yard residues. The product shall be well composted, free of viable weed seeds and contain material of a generally humus nature capable of sustaining growth of vegetation, with no materials toxic to plant growth. Compost shall have the following properties:

<u>Parameters</u>	<u>Range</u>
PH	6.5 - 7.5
Moisture content	35% - 55%
Soluble Salts	< 4.0 mmhos (dS)
C:N ratio	15 - 30:1
Particle Size	< 1/2"
Organic Matter Content	> 40%
Bulk Density	< 1000 lbs./cubic yard
Foreign Matter	< 1 % (dry weight)

Compost generator shall also provide minimum available nitrogen and other macro and micro nutrients to determine fertilizer requirements. Generator shall supply documentation showing state approval for intended use.

2.4 ROOT ZONE MIX

- A. Mixing Materials: Mixing of the sand, peat and soil mixture for the root zone mix must be blended by an experienced operator.
- B. Physical performance Evaluation of the root zone mix will be in accordance with the guidelines set forth in ASTM standard F 2396.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Inspect all surfaces and verify that they are in proper condition to receive the work of this Section.
- B. Beginning of installation means acceptance of existing project conditions.

3.2 ROOT ZONE MIX RATIOS

- A. Upon approval of the processed loam, sand and compost components, the owners testing agents shall blend the components to determine the correct ratio of sand and compost to create the root zone mix. This ratio of sand and compost will be based on laboratory testing and performance guidelines established by these specifications.
- B. For bidding purposes, the mix ratio will contain approximately 40 to 50% native screened loam, 50% sand and 5 to 10% compost by volume. Actual ratios will be determined based on testing of materials.
- C. The root zone mix developed by the owner's testing agent will establish the required mix ratio and specifications for approval or rejection of all quality control submittals during construction. Performance Testing: ASTM testing procedures for sand based athletic fields shall be used for performance testing.

3.3 PLACEMENT

- A. The Contractor shall furnish and spread Root Zone Mix to the depths shown on the contract drawings, which depth shall be the minimum required depth after settlement. No compaction shall be required beyond that extent necessary to place sod or for the establishment of seed.
- B. Root Zone Mix shall be spread in such a manner as to establish a loose, friable seedbed.

- C. Under no circumstances will loaded rubber tired vehicles in excess of 1 ton be allowed on the gravel base prior to or during the spreading of the root zone mix.
- D. Finish grades shall be verified by the Contractor using laser operation survey instruments with a tolerance of +/-1 inch.

3.4 AMENDMENTS

- A. The Contractor shall apply as necessary fertilizer, lime and other amendments to the soil in accordance with the soil laboratory's and landscape architects recommendations.

End of Section

SECTION 32 9219

SEEDING

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. Seeding.
- 2. Hydroseeding.
- 3. New England Conservation Wetland Mix
- 4. Erosion-control material(s).

B. Related Sections:

- 1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
- 2. Division 31 Section "Earth Moving" for excavation, filling and backfilling, and rough grading.
- 3. Division 32 Section "Plants" for border edgings.
- 4. Division 33 Section "Subdrainage" for subsurface drainage.

1.3 DEFINITIONS

- A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
 - 1. All use of pesticides shall conform with the Connecticut DEEP requirements.

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- E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
 - F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
 - G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
 - H. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
 - I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.
- B. of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- C. Qualification Data: For qualified landscape Installer.
- D. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- E. Material Test Reports: For standardized ASTM D 5268 topsoil.
- F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.

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2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section "Quality Requirements."
 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation maintenance specialty area(s), designated CLT-Exterior.
 - b. Certified Turfgrass Professional, designated CTP.
 - c. Certified Turfgrass Professional of Cool Season Lawns, designated CTP-CSL.
 5. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
 6. Pesticide Applicator: State licensed, commercial.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for turf growth.
 - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

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- D. Preinstallation Conference: Conduct conference at Project site at least one week prior to turf installation.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Contractor responsible for all maintenance until Substantial Completion.
 - 1. Spring Planting: April 1 - June 15.
 - 2. Fall Planting: August 15 - October 1.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE SERVICE

- A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
 - 1. Seeded Turf: 90 days from date of planting completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

- B. Initial Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established (determined by Landscape Architect and Construction Manager), but for not less than 90 days from date of planting completion.
- C. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 PRODUCTS

2.1 TOPSOIL

- A. Shall be clean, fertile, friable and well draining; not to contain materials harmful to plant life. All topsoil to be free of any subsoil earth clods, sods, stones over the specified size in any dimension, sticks, roots, weeds, litter and other deleterious material. Topsoil shall be uniform in quality and texture, and contain specified organic matter and mineral elements necessary for sustaining healthy plant growth. Rock fragments over one-inch in diameter shall not exceed two-percent by volume. Topsoil shall be free of any toxic chemical, waste or any material or condition that would prevent the establishment of suitable lawn. All imported off-site topsoil shall be obtained from a single source. Topsoil shall have a pH of 6.0 to 8.0. Organic matter contents shall be 4 to 8%. Soil texture shall meet the USDA Soils Texture Classification percentages for sand, silt and clay for 'Sandy Loam' with not less than 75% sand.

2.2 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: State-certified seed of grass species as follows:
- C. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Manhattan 5 Seed Mix.

2.3 SOD

- A. Manhattan 5 Seed Sod

2.4 MEADOW GRASSES AND WILDFLOWERS

- A. New England Conservation Wetlands Mix: Fresh, clean, and dry new seed, of mixed species as follows:
 - 1. Mud Plantain (*Alisma plantago-aquatica*), Swamp Milkweed (*Asclepias incarnata*), New York Aster (*Aster novi-belgii*), Nodding Bur Marigold (*Bidens cernua*), Bristly/Cosmos Sedge (*Carex cosmosa*), Fringed Sedge (Nodding) (*Carex crinita*), Hop Sedge (*Carex*

lupulina), Lurid Sedge (Shallow) (*Carex lurida*), Blunt Broom Sedge (*Carex scoparia*), Fox Sedge (*Carex vulpinoidea*), Spotted Joe Pye weed (*Eupatorium maculatum*), Boneset (*Eupatorium perfoliatum*), Rattlesnake Grass (*Glyceria canadensis*), Fowl Mannagrass (*Glyceria striata*), Soft Rush (*Juncus effusus*), Square Stemmed Monkey Flower (*Mimulus ringens*) Sensitive Fern (*Onoclea sensibilis*), Green Bulrush (*Scirpus atrovirens*), Wool Grass (*Scirpus cypernus*), Soft-Stem Bulrush (*Shoenoplectus tabernaemontani*) (ex- *S. validus*), Blue Vervain (*Verbena hastata*).

- B. Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than two parts seed carrier to one part seed.

2.5 WETLANDS RESTORATION

- A. New England Wetmix (wetlands seed mix) shall be as provided by New England Wetland Plants, Inc, Massachusetts (phone 413-548-8000), Blackledge River Nursery, Marlborough, CT or approved equal.

2.6 \INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
 2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
 3. Provide lime in form of ground dolomitic limestone or calcitic limestone depending on recommendation from soil analysis.
- B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- D. Aluminum Sulfate: Commercial grade, unadulterated.
- E. Perlite: Horticultural perlite, soil amendment grade.
- F. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.
- G. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
- H. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
- I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.7 ORGANIC SOIL AMENDMENTS

- A. Amendments, fertilizers, and conditioners shall be recommended in the Topsoil Test Report.
- B. Compost: The compost shall be a stable, humu-like material produced from the aerobic decomposition of organic residues. The Carbon/nitrogen ration shall be in the range of 10:1 to 25:1. The organic matter shall be at least 40% on an oven dry basis. 100-percent of the material shall pass a ½ inch screen. Soluble salts shall not exceed 4.0 mmhos cm-1. The pH shall be between 5.5 to 8.0. No man-man inert debris such as glass, metal, wood, masonry shall be visible and shall not exceed 1% dry weight.
 - 1. Heavy metals regulated by the EPA measured in the parts per million shall not exceed the allowable limits.
- C. Organic fertilizers are derived from several sources. Bonemeal in first paragraph below is organic and primarily phosphorous, has an alkaline reaction, and is nonburning. Other organic fertilizers include blood meal, cottonseed meal, seaweed meal, soybean meal, alfalfa meal, and blends of these materials.
- D. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.
- E. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- F. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- G. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.8 PLANTING SOILS

- A. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth. Mix ASTM D 5268 topsoil with the soil amendments and fertilizers in the quantities recommended by the soil analysis to produce planting soil.
- B. Planting Soil: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

1. Supplement with another specified planting soil when quantities are insufficient.
 2. Mix existing, native surface topsoil with the soil amendments and fertilizers in the quantities recommended by the soil analysis to produce planting soil.
- C. Planting Soil: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the soil amendments and fertilizers in the quantities recommended by the soil analysis to produce planting soil.

2.9 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.
- C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
1. Organic Matter Content: 50 to 60 percent of dry weight.
 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.10 PESTICIDES

- A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

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- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
 - C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.11 EROSION-CONTROL MATERIALS

- A. A. enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.
- C. Erosion-Control Mats: Cellular, non-biodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of 3-inch minimum nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Invisible Structures, Inc.; Slopetame 2.
 - b. Presto Products Company, a business of Alcoa; Geoweb.
 - c. Tenax Corporation - USA; Tenweb.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

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- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.
- B. Verify topsoil placement has been completed and accepted. Verify required permeability has been tested and approved. All disturbed areas not developed otherwise shall be developed as lawn as indicated on the Drawings and as specified. Provide additional topsoil where and as required to properly meet all proposed finish grades. Remove weeds, debris, foreign matter and stones having any dimensions greater than $\frac{3}{4}$ ".
- C. Fine grade to a smooth uniform surface. Grades shall be within specified tolerances. The entire area shall present an even grade with no depressions where water will stand. Topsoil shall be smooth blended to existing finish grades around trees, erosion control devices and adjacent existing conditions, maintain existing surface drainage patterns. Smoothly round-off all top and toe of slopes. Reinstall erosion control devices and protective fencing as required.
- D. For spring seeding provide sidurn for pre-emergence crabgrass control. Repeat applications as needed and in accordance with the manufacturer's recommendation.
- E. Determine the bulk density of the topsoil prior to approval of finish grade, using an approximate method outlined in C.A. Black (ed) Methods of Soil Analysis, Part 1, American Society of Agronomy, 1965. Final bulk density of the topsoil shall have a mean value of approximately 1.35 g cm⁻³ (85 lbs. per cu. ft.) taken from 5 samples from each field with no value exceeding 1.40 g cm⁻³ (88 lbs. per cu. ft.).
- F. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches (6" in areas used for staging, parking or construction activity. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
 - 2. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.

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- a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
3. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
 - b. Reduce elevation of planting soil to allow for soil thickness of sod.
- G. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of fine texture.
 - a. Apply superphosphate fertilizer directly to surface soil before loosening.
 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- H. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Final smoothing is to leave a firm and level surface with no soft spots. Limit finish grading to areas that can be planted in the immediate future.
- I. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- J. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- 3.4 PREPARATION FOR EROSION-CONTROL MATERIALS
- A. Prepare area as specified in "Turf Area Preparation" Article.
 - B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

- C. Fill cells of erosion-control mat with planting soil and compact before planting.
- D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 PREPARATION FOR GRASS-PAVING MATERIALS

- A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions.
- B. Install base course and proprietary growing mix as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.
- C. Install paving mat and fasten according to paving-material manufacturer's written instructions.
- D. Before planting, fill cells of paving mat with planting soil and compact according to manufacturer's written instructions.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.6 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 3 to 4 lb/1000 sq. ft..
- C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.

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- F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
 - 1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
 - 2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft.. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
 - G. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.7 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with nonasphaltic tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
 - 3. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

3.8 TURF RENOVATION

- A. Renovate existing turf.
- B. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
 - 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
 - 2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing turf.

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- F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
 - G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
 - H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
 - I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
 - J. Apply seed and protect with straw mulch as required for new turf.
 - K. Water newly planted areas and keep moist until new turf is established.

3.9 TURF MAINTENANCE

- A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches. The contractor shall provide all irrigation equipment and water as necessary to irrigate the seeded areas daily with ¼ acre inch of water per day using 3 sets to keep the surface moist and to maintain soil moisture at or near field capacity so that the seedbed does not dry out and adequate rooting takes place. The amount of water per dy and the number of sets may be adjusted at the request of the Owner. The irrigation schedule shall further be adjusted after the seedling plants and sod are rooted. The quantity of water used per day shall be recorded and reported daily to the Construction Manager for the first three week from seeding and weekly thereafter.
- C. Mow turf at 5 day intervals commencing as soon as the seedlings in the seeded areas reach 2 inches in height. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow bentgrass to a height of 1/2 inch or less.
2. Mow bermudagrass to a height of 1/2 to 1 inch.
3. Mow carpetgrass perennial ryegrass to a height of 1 to 2 inches.
4. Mow Kentucky bluegrass annual ryegrass chewings red fescue to a height of 1-1/2 to 2 inches.
5. Mow turf-type tall fescue to a height of 2 to 3 inches.

D. Turf Post Fertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.10 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 2 by 2 inches.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.11 MEADOW

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.

B. Sow seed at a total rate of 5 oz./1000 sq. ft..

C. Brush seed into top 1/16 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas from hot, dry weather or drying winds by applying peat or compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

E. Water newly planted areas and keep moist until meadow is established.

3.12 MEADOW MAINTENANCE

A. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 3. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.
1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 2. Water meadow with fine spray at a minimum rate of 1/2 inch per week for six weeks after planting unless rainfall precipitation is adequate.

3.13 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.14 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas. On a daily basis.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION

SECTION 33 3100 - SANTARY SEWER

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Installation of sanitary pipe and fittings.
 - 2. Installation of specials, connection chimneys, laterals, outlets, and joint materials.
 - 3. Installation of manholes.
- B. Contractor shall coordinate work between all Contractors, sections, and trades required for the proper completion of the work.
- C. Contractor is solely responsible for obtaining permits or approvals which may be required to perform the work of this section, including all costs, fees and taxes required or levied. Notify and obtain such permits or approvals from all agencies having jurisdiction prior to starting work.

1.2 REFERENCE STANDARDS

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM).
 - 1. ASTM A 47/A 47M - Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process.
 - 2. ASTM A 48 - Standard Specification for Gray Iron Castings.
 - 3. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
 - 5. ASTM A 536 - Standard Specification for Ductile Iron Castings.
 - 6. ASTM A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
 - 7. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 8. ASTM A 74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
 - 9. ASTM A 746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
 - 10. ASTM C 12 - Standard Practice for Installing Vitrified Clay Pipe Lines.

11. ASTM C 14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
12. ASTM C 55 - Standard Specification for Concrete Building Brick.
13. ASTM C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
14. ASTM C 94/C 94M - Standard Specification for Ready-Mixed Concrete.
15. ASTM C 139 - Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.
16. ASTM C150 - Standard Specification for Portland Cement.
17. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes.
18. ASTM C270 - Standard Specification for Mortar for Unit Masonry.
19. ASTM C387 - Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
20. ASTM C 425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
21. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
22. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
23. ASTM C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
24. ASTM C 507 - Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
25. ASTM C 564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
26. ASTM C700 - Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
27. ASTM C 1628 - Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets.
28. ASTM C 828 - Low-Pressure Air Test of Vitrified Clay Pipe Lines.
29. ASTM C877 - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.
30. ASTM C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
31. ASTM C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.
32. ASTM C 924 - Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.

33. ASTM C 969 - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
34. ASTM C 972 - Compression-Recovery of Tape Sealant.
35. ASTM C 990 - Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.
36. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension.
37. ASTM D 624 - Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
38. ASTM D 1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
39. ASTM D 1785 - Standard Specification for Poly (Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120.
40. ASTM D 2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
41. ASTM D 2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
42. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
43. ASTM D 2412 - Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
44. ASTM D 2464 - Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
45. ASTM D 2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
46. ASTM D 2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
47. ASTM D 2680 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.
48. AASTM D 2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
49. ASTM D 2996 - Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
50. ASTM D 2997 - Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
51. ASTM D 3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
52. ASTM D 3139 - Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

53. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
 54. ASTM D 3262 - "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.
 55. ASTM D 3350 - Polyethylene Plastics Pipe and Fittings Materials.
 56. ASTM D 3753 - Glass-Fiber-Reinforced Polyester Manholes and Wetwells.
 57. ASTM D 3840 - "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications.
 58. ASTM D 4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.
 59. ASTM D 4161 - "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.
 60. ASTM D 4396 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Nonpressure Applications.
 61. ASTM F 402 - Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.
 62. ASTM F 405 - Corrugated Polyethylene (PE) Tubing and Fittings.
 63. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 64. ASTM F 679 - Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 65. ASTM F 714 - Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
 66. ASTM F 758 - Smooth-Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage.
 67. ASTM F 794 - Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
 68. ASTM F 894 - Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.
 69. ASTM F 949 - Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings.
 70. ASTM F 1336 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gasketed Sewer Fittings.
 71. ASTM F 1803 - Standard Specification for Poly (Vinyl Chloride)(PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter.
- D. American Water Works Association (AWWA).
1. "PVC Pipe - Design and Installation", M23 (latest edition. and applicable supplements thereto).

2. "Concrete Pressure Pipe", M9 (latest edition and applicable supplements thereto).
 3. ANSI/AWWA C104/A21.4 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 4. ANSI/AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 5. ANSI/AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings for Water.
 6. ANSI/AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 7. ANSI/AWWA C150/A21.50 - Thickness Design of Ductile-Iron Pipe.
 8. ANSI/AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
 9. ANSI/AWWA C153/A21.53 - Ductile-Iron Compact Fittings for Water Service.
 10. ANSI/AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
- E. American Concrete Pipe Association (ACPA).
1. ACPA 01-103 - Concrete Pipe and Box Culvert Installation (latest revision and applicable supplements thereto).
- F. UNI-BELL PVC PIPE ASSOCIATION (UBPPA).
1. UBPPA UNI-B-6 (1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe.
- G. American Association of State High and Transportation Officials (AASHTO).
1. Standard Specifications for HS-20, Highway Loading (AASHTO H-20).

1.3 SUBMITTALS

- A. Submit to Engineer for his approval manufacturer's name with details of the pipe, fittings, and joint offered before ordering. Engineer reserves the right to have the manufacturer submit to them a printed certified set of material specifications certifying to the manufacturer's conformity with this Section.
- B. Product data for all materials provided under this Section.
- C. Prior to ordering material, submit shop drawings and descriptive literature showing dimensions, joint and other details of all materials to be furnished under this Section. Such shop drawings shall include, but not necessarily be limited to, joint and other details for precast manholes, manhole frames and covers, and flexible joint sealant for manholes.
- D. Samples of each size and type of pipe to be utilized. No pipe shall be ordered or delivered until Engineer has approved the pipe material.
- E. As-Built Drawings
 1. Submit two (2) copies of As-Built Drawings upon completion and acceptance of work.

2. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall include a minimum of three (3) ties showing the distance to each catch basin and manhole, and the location of service connections measured from fixed permanent objects. As-Built drawings shall also contain any additional information required by Engineer.

1.4 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.
- B. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction.
- C. Sample pipe for testing, when requested by Engineer, shall be furnished by Contractor in sufficient numbers. The Contractor and/or the pipe manufacturer shall make the facilities and services for making the load tests available.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Storage
 1. Manufacturer shall package the pipe in a manner designed to deliver the pipe to the Project Site neatly, intact, and without physical damage. Transportation carrier shall use an appropriate method to ensure the pipe is properly supported, stacked, and restrained during transport. Inspect materials delivered to site for damage; store with minimum of handling.
 2. Unloading of the pipe should be controlled so as not to collide with the other pipe sections or fittings, and care should be taken to avoid chipping or spalling, especially to the spigots and bells. For manhole sections, cone sections, bases, fittings and other precast appurtenances, utilize lifting holes or lifting eyes provided.
 3. In cold weather conditions, use caution to prevent impact damage. Handling methods considered acceptable for warm weather may be unacceptable during cold weather.
 4. Storage:
 - a. Store materials on site in enclosures or under protective coverings. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.
 - b. Pipe shall be stored on clean, level ground to prevent undue scratching or gouging.
 - c. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials under cover out of direct sunlight. Provide additional storage measures in accordance with the manufacturer's recommendations. Discard materials if storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

- d. Metal Items: Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.
- e. Cement, Aggregate, and Reinforcement: As specified in Section 033200 – Site Cast-in-Place Concrete.
- f. Store manhole units in an upright position.

PART 2 PRODUCTS

2.1 GENERAL

- A. Products furnished under this Section which are damaged or found defective in any way prior to being set in place and final acceptance, may be rejected. Engineer may reject an entire lot of pipe should the sample pipe from such lot fail to meet requirements.

2.2 POLYVINYL CHLORIDE (PVC) GRAVITY PIPE

- A. Pipe, 4 inch to 15 inch diameter: ASTM D 3034, SDR-35. Elastomeric gasket joints, retained gaskets, part of a complete pipe section and supplied as such.
- B. Pipe, 18 inch to 36 inch diameter: ASTM F 679. Elastomeric gasket joints, retained gaskets, part of a complete pipe section and supplied as such.
- C. PVC Cell classification: 12454 or 12364, ASTM D1784.
- D. Pipe shall have a minimum pipe stiffness that equals or exceeds 46 psi (lbs / in- in).
- E. Pipe shall be marked along the outside of the barrel with the following:
 - 1. The manufacturer's name or trademark.
 - 2. The standard to which it conforms/ASTM Designation.
 - 3. Pipe size.
 - 4. Material designation code/PVC cell classification.
 - 5. SDR number or schedule number.
- F. Standard length of pipe: maximum of 20 feet with the following exceptions.
 - 1. Length of 6–inch pipe shall be a maximum of 13 feet unless otherwise approved by Engineer.
 - 2. Pipe used in house connections and/or laterals shall not exceed 6.5 feet in length unless otherwise approved by Engineer.
- G. PVC Plastic Gravity Joints and Jointing Material.
 - 1. Joints: ASTM D3213, gasketed, bell-and-spigot, push-on type.
 - 2. Gaskets: ASTM F 477. Since each pipe manufacturer has a different design for push-on joints, gaskets shall be part of a complete pipe section and provided as such. Gaskets may be factory installed or field installed as recommended by the pipe manufacturer. Lubricant shall be as recommended by the pipe manufacturer.

- H. Fittings: SDR-35, ASTM D 3034 and ASTM F1336, specifications as pipe.
- I. The manufacturer shall provide waterstops acceptable to Engineer, which shall be applied to the outside of the plastic pipe where the pipe is to be enclosed in any structure where concrete or mortar is used to prevent leakage along the outer wall of the barrel of the pipe.
- J. No single piece of pipe shall be laid on any project covered by these specifications unless it is found to be generally straight. Such pipe shall have a maximum ordinate as measured from the concave side of the pipe not to exceed 1/16 inch per foot of length. If the deviation from straightness exceeds this requirement, then the particular piece of pipe shall be rejected.

2.3 JOINT LUBRICANT

- A. As specified by pipe manufacturer, ANSI/AWWA C111/A21.11.

2.4 CONCRETE MANHOLE

- A. Reinforced precast concrete base, riser, and top: ASTM C 478. Precast manhole sections shall consist of smooth circular sections in standard nominal inside diameters. Type and dimensions as indicated on the Drawings.
 - 1. Diameter: 48-inches unless otherwise indicated.
 - 2. Concrete: 4,000 psi.
 - 3. Precast concrete manhole sections shall be free from cracks, damaged joints, exposed reinforcing, aggregate pockets, spalls, and dimensional distortions or other irregularities. Lifting holes shall be filled with mortar, or other approved material.
 - 4. Bottoms shall be integrally cast unless specialty bases (“Dog-House”) at points of connection to existing sewer mains are indicated on the Drawings or otherwise proposed for use. Unless indicated on the Drawings, any special bases or riser used must be detailed in shop drawings and submitted for approval.
 - 5. Riser sections: As required to provide depths indicated.
 - 6. Top Section: Concentric-cone type, unless eccentric-cone or flat-slab-top type is indicated. Cones shall have the same wall thickness and reinforcement as riser sections. If required or called-for, flat slab shall be a minimum of 8-inches thick designed to carry AASHTO H-20 loading with one foot cover and conform to ASTM C478.
 - 7. External damp-proofing: Asphalt, ASTM D449, Type A.
 - 8. Openings or "knockouts" in precast units shall be located as shown on the Drawings and to accommodate the inflow and outflow pipe orientation required. Openings shall sized sufficiently to permit passage of the largest outside dimension of pipe or fittings. Prior to ordering precast manhole bases, all angles between incoming pipes are to be field checked to incorporate possible line changes required in the field layout.
- B. Gaskets for joints between manhole sections: Butyl rubber, ASTM C 443.
- C. Grade Rings: ASTM C 478, precast reinforced concrete, 1 inch to 4 inch thickness, diameter to match manhole and frame.
- D. Mortar: Packaged, ASTM C 387 or as Specified in Section 033200 – Site Cast-in-Place Concrete.

- E. Frame and Cover: Ductile Cast Iron, ASTM A536, Grade 60-40-18.
- F. Frame and Cover: Grey Cast Iron, ASTM A48, Class 35B.
 - 1. Cover: 26 inch diameter, non-vented with non-penetrating pickholes. Unless otherwise detailed or indicated, covers shall be cast with 1-1/2 inch wide, raised letters, indicating "SANITARY SEWER".
 - 2. Frame and cover shall be supplied as a pair from the same manufacturer. Castings shall be of tough, even-grained iron, free from scale, lumps, blisters, sand-holes and other injurious defects, and of the size and type shown on the drawings. Frames and covers shall have machined bearing surfaces to seat firmly and prevent rocking and rattling under traffic loads. Before leaving the foundry, castings shall be thoroughly cleaned, subjected to hammer tests for soundness and given two coats of coal tar pitch varnish.
- G. Resilient connectors for joints between manhole and pipes entering manhole: Continuous boot of 3/8 inch minimum thickness neoprene, ASTM C 923 or ASTM C 990. Boots shall be either cast into the manhole wall or installed into a cored opening using internal compression rings. Installed boot shall result in a water-tight connection meeting the performance requirements of ASTM C 443.
- H. Manhole Steps: ASTM C 478 and OSHA 29 CFR 1910.27, drop front or equivalent. Steps shall be nine inches in depth and at least twelve inches in width with an abrasive step surface.
 - 1. Composite Plastic-Steel: One-half (1/2) inch deformed steel reinforcing rod, ASTM A615, Grade 60, encapsulated in a co-polymer polypropylene plastic, ASTM D2146, Type II, Grade 16906.
 - 2. Steps shall be placed in vertical alignment as indicated on the Drawings. Steps shall be uniformly spaced not more than sixteen inches (16") on center, including the spacing between the top step and the manhole cover. Steps shall be embedded in the wall a minimum distance of 4 inches in either cast or drilled holes. Steps shall not be driven or vibrated into fresh concrete and shall withstand a pullout resistance of 2000 lbs when tested in accordance with ASTM C 497. Each step shall project a minimum of 5 inches from the wall measured from the point of embedment.

2.5 DROP MANHOLE

- A. Drop inlet shall be constructed with ductile iron gravity sewer pipe laid in undisturbed soil in conformance with ASTM A746-82. Adapt to PVC with Fernco coupling or approved equivalent.
- B. Vertical drop pipe shall be 8", 10", or 12" maximum SDR 35 PVC with 90 degree short bend radius shall conform to ASTM D3034.
- C. Vertical drop pipe shall be anchored a minimum of every 4 feet with 1/8" x 1-1/2" type 304 stainless steel pipe straps set as ordered with lag bolts and shields.

2.6 MORTAR

- A. Mortar: ASTM C 387.
 - 1. Portland Cement: ASTM C 150, Type I.

2. Sand: ASTM C 144.
3. Hydrated Lime: ASTM C 207.
4. Water: Potable.
5. Mix proportions for manhole rims and covers: 1 part portland cement, 2 parts sand, and 1/4 part hydrated lime by dry volume. Hydrated lime shall not exceed 10 percent by weight of the total dry mix. Quantity of water in mixture shall be sufficient to produce a stiff, workable mortar, but in no case shall exceed 5-1/2 gallons of water per sack of cement.
6. Mix Proportions for invert construction: 1 part portland cement and 2 parts sand by volume. Quantity of water in mixture shall be sufficient to produce a stiff, workable mortar, but in no case shall exceed 5-1/2 gallons of water per sack of cement.

2.7 GREASE TRAP

- A. Grease trap units shall be either made of precast concrete or fiberglass of the dimensions necessary to provide the capacity shown on the plans and to fit within the location and elevations shown on the plans.
- B. Units shall be as manufactured by United Concrete Products, Inc. (Yalesville, CT); Rotondo Precast (Rehoboth, MA); Sparkling Clear Industries (Houston, TX), or approved equivalent.
- C. Precast sections shall be cured by an approved ASTM method and shall not be shipped, nor subject to loading, until the concrete compressive strength has attained 4,000 psi. Portland cement shall be Type II, ASTM C150-07.
- D. Precast units shall be designed for the following loads and possible combinations thereof:
 1. H-20 loading with one foot of cover, manhole riser with frame and cones, plus the weight of the soil above.
 2. Weight of precast structure.
 3. High groundwater/buoyancy.
 4. Initial handling and erection loadings.
- E. Precast Unit Joints: Butyl rubber gasket joints, ASTM C990.
- F. Fiberglass units shall be made of glass-fiber construction that uses a thixotropic polyester resin specifically for the manufacturer of reinforced products. The material shall be inert, non-corrosive and impervious to retained wastes.
- G. Fiberglass units shall be designed for the following loads and possible combinations thereof:
 1. H-20 loading with one foot of cover, manhole riser with frame and cover, plus the weight of soil above.
 2. Weight of structure.
 3. High groundwater/buoyancy.
 4. Initial handling and installation loadings.

- H. Unit manufacturer shall provide cleanout, sample and ventilation ports and a grease level monitoring and alarm system.

2.8 BEDDING

- A. Bedding for pipes: Unless otherwise directed by Engineer, bedding shall consist of screened gravel, maximum size 3/4 inches and minimum size 3/8 inches.
- B. Bedding for Manholes: Screened Gravel or Crushed Stone, well graded in size from 3/4 inch to 3/8 inch consisting of clean, hard, and durable fragments. No limestone shall be permitted.

PART 3 EXECUTION

3.1 GENERAL

- A. Inspect each pipe, fitting or other material before and after installation; replace those found defective and remove from Project Site.
- B. Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry or hoist, do not drag, pipe to trench. Provide proper facilities for lowering sections of pipe, manholes or other appurtenances into trenches and excavations without damage.
- C. Wyes, tees and bends and adapters may not be explicitly indicated on the drawings but shall be installed as required to route pipe as indicated. Plans for such fittings showing cross sectional views with dimensions shall be provided by Contractor to Engineer for approval prior to use.
- D. Dry conditions shall be maintained at all times and under no circumstances shall pipe be laid or appurtenances installed in water.

3.2 LOCATION

- A. Where the location of the sewer is not clearly defined by dimensions on the drawings, do not lay sewer line closer horizontally than ten (10) feet to a water main or service line.
- B. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least two (2) feet below bottom of water line.
- C. Where sanitary sewer lines pass above water lines, encase sewer in concrete for a distance of ten (10) feet on each side of the crossing, or substitute rubber-gasketed pressure pipe for the pipe being used for the same distance.
- D. Where sanitary sewer lines pass below water lines, lay pipe so that no joint in the sewer line will be closer than three (3) feet, horizontal distance, to the water line.
- E. Sanitary piping installation parallel with water line:
 - 1. Normal conditions: Sanitary piping or manholes shall be laid at least ten (10) feet horizontally from a water line whenever possible. The distance shall be measured edge-to-edge.
 - 2. Unusual conditions: When local conditions prevent a horizontal separation of ten (10) feet, the sanitary piping or manhole may be laid closer to a water line provided that:

- a. The top (crown) of the sanitary piping shall be at least 18 inches below the bottom (invert) of the water main.
 - b. Where this vertical separation cannot be obtained, the sanitary piping shall be constructed of AWWA-approved ductile iron water pipe pressure tested in place without leakage prior to backfilling.
 - c. The sewer manhole shall be of watertight construction and tested in place.
- F. Installation of sanitary piping crossing a water line:
1. Normal conditions: Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.
 2. Unusual conditions: When local conditions prevent a vertical separation described above, use the following construction:
 - a. Sanitary piping passing over or under water lines shall be constructed of AWWA-approved ductile iron water pipe, pressure tested in place without leakage prior to backfilling.
 - b. Sanitary piping passing over water lines shall, in addition, be protected by providing:
 - 1) Vertical separation of at least 18 inches between the bottom of the sanitary piping and the top of the water line.
 - 2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.
 - 3) That the length, minimum 20 feet, of the sanitary piping be centered at the point of the crossing so that joints shall be equidistant and as far as possible from the water line.
- G. Sanitary sewer manholes: No water piping shall pass through or come in contact with any part of a sanitary sewer manhole.
- H. Unless shown on the Drawings or otherwise specified, the minimum cover for sanitary sewer pipe under roads shall be three (3) feet six (6) inches, and in grassed areas shall be four (4) feet.

3.3 EARTHWORK

- A. Excavation, the type of materials to be used in bedding and backfilling, and the method of placement shall conform to the requirements of Section 312310 – Earthwork and the details shown on the Drawings.
- B. Trenches should be excavated to the dimensions and grade specified on the Drawings or as ordered by engineer. The width of the trenches should be kept to the minimum required for installation of pipe sections.
 1. Maximum trench width in soil: 1.25 times outside pipe diameter, in inches, plus one (1) foot measured at the springline of the pipe.
 2. Maximum trench width in rock: Four (4) feet plus outside pipe diameter measured at the springline of the pipe.

- C. The bottom of trenches shall be sufficiently graded to ensure uniform bearing for the full length of all pipes.
- D. Backfill, with approved materials, and properly compact the following:
 - 1. Over excavated areas
 - 2. Soft, unstable, or unsuitable material.
- E. Trenches shall be maintained in a safe condition at all times. Contractor shall furnish and employ such stay braces, sheeting, shoring, pumps, etc., as may be necessary for the proper completion of work, the protection of property and the safety of the public, employees of Contractor, Local Public Agencies, the Engineer, or the State; all in accordance with the current regulations of the Applicable Safety Code and pertinent local ordinances and regulations.
- F. Contractor shall be entirely and solely responsible for the adequacy and sufficiency of all supports and of all sheeting, bracing shoring, underpinning, cofferdamming, etc. The Contractor shall assume the entire and sole liability for damages on account of injury to persons or damage to adjacent pavements and public and private property (including but not limited to, the Work under construction, existing buildings, facilities, etc.) which injury or damage results directly from Contractor's failure to install or to leave in place adequate and sufficient supports, sheeting, bracing, underpinning, cofferdamming, etc.
- G. When blasting is required for the rock excavation, adequate provisions for safety shall be provided and such work shall be performed in compliance with applicable local requirements.
- H. Backfill: Trenches shall be backfilled only after pipe has been inspected and approved and locations of pipes and appurtenances have been recorded.

3.4 PIPE INSTALLATION

- A. All pipe shall be installed per the recommendations of the pipe manufacturer, unless otherwise specified.
- B. Clean and dry surfaces receiving lubricants, cements, or adhesives. Affix gaskets to pipe not more than 24 hours prior to the installation of the pipe. Protect gaskets from sun, blowing dust, and other deleterious agents at all times. Before installation of the pipe, inspect gaskets and remove and replace loose or improperly affixed gaskets. Align each pipe section with the previously installed pipe section, and pull the joint together.
- C. Commencing at the lowest point in the system, the pipe and fittings shall be carefully laid true to line and grade with the bell or groove- end upgrade.
- D. A stopper shall be kept in the pipe mouth when the pipe laying is not in progress.
- E. The ends of pipe, which enter masonry, shall be neatly cut to fit the inner face of the masonry.
 - 1. The upper surface of the screened gravel shall be shaped as necessary to provide proper grade for the pipe to be laid thereon, bell holes shall be made in the screened gravel so the pipe shall be supported on its barrel portion only, and the pipe laid thereon to line and grade in the manner described in these Specifications.

- F. When the pipe is properly positioned, screened gravel, unless otherwise required by the drawings or Engineer, shall be pulled or scraped up against the pipe and rammed into place along the barrel of the pipe only, to firmly hold the pipe in position. Care shall be taken during these operations to assure that the pipe is not disturbed.
- G. Screened Gravel Haunching and Sand Stop:
1. All pipe and laterals connected thereto, shall be haunched with bedding from the foundation to a point at least to the top of the pipe and to this same elevation out to the trench wall. Care shall be taken when placing bedding in haunching, to assure that the pipe is not disturbed.
 2. Contractor shall use any means necessary to assure firm compaction of haunching and adequate side support for the pipe.
 3. Contractor shall provide and install a filter fabric sand stop per Section 02290 for the full trench width for all sanitary sewer mains and laterals. Filter fabric shall be placed on top of the screened gravel prior to placement of 12" gravel/sand cushion. All costs for furnishing and placing of the filter fabric shall be included in the price bid per foot of pipe of all sizes.
- H. Backfill trenches from the top of the screened gravel haunching and sand stop to 12" above the top of pipe with firmly compacted sand or fine gravel or other suitable material exercising care so as not to damage or disturb the pipe.
- I. Backfill from 12" above the top of pipe to top of trench with bank run gravel, sand, or other approved material in roadway areas, otherwise suitable existing material may be used if approved by Engineer.
- J. Fill on both sides of pipe and up to a depth of 12 inches over top of pipe shall be placed carefully by hand in layers, 6 inches thick, and each layer will be tamped and compacted before the next layer is placed. Care must be taken that the fill is compact and tight under the lower half of the pipe. Remaining backfill shall be placed in layers of not more than 12 inches in depth after compaction and shall be thoroughly compacted by means of mechanical rammers or vibrators or by pneumatic tampers. Hand tampers shall be used only around the pipe as approved by Engineer. All voids along sides of trench, behind sheeting, under bracing or other objects, shall be completely and carefully filled, using such fine materials, hand labor and tools as may be necessary. All backfill materials shall be compacted to a minimum of 95% of the maximum dry density as determined by AASHTO T-180 Method D or as directed by Engineer.
- K. At Engineer's discretion, the Contractor may compact the backfill from 12 inches over the pipe to finish grade by means of a Ho-Pac. Engineer shall also have the right to approve or disapprove the compaction equipment to be used and also the height of backfill to be compacted in one lift.
- L. Backfill, screened gravel foundation and haunching shall be provided and installed as shown on the typical trench cross-section shown on the Drawings.

3.5 SPECIAL REQUIREMENTS

- A. The following subarticles supplement execution requirements set forth in Article 3.4.
- B. Installation of PVC Plastic Piping

1. Install pipe and fittings in accordance with Article 3.4 and ASTM D 2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D 2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.6 MANHOLE INSTALLATION

- A. Precast reinforced concrete manhole sections shall be set so as to be vertical and with section in true alignment. Joints of the base and precast section shall be formed and sealed with "O" ring type rubber gaskets. Joints shall be painted with mortar and exterior joints thoroughly tooled so as to be slightly concave with a hard polished surface free from drying cracks. Interior joints shall be tooled flush in a similar manner. Mortar shall be as herein specified for brick masonry.
- B. All holes in sections, used for their handling, shall be thoroughly plugged with mortar. Finish smooth and flush with adjoining surfaces.
- C. Furnish manhole and catch basin frames, covers and/or grates conforming to the Drawings and as specified herein.
- D. Manhole frames shall be set with the tops conforming accurately to the grade of or finished ground surface or as indicated on the plans or directed. Adjust to grade with clay bricks and mortar, not to exceed five brick courses. Frames shall be set concentric with the top of the masonry and in a full bed of mortar so that the space between the top of the manhole masonry and the bottom flange of the frame shall be completely filled and made watertight. A thick ring or mortar extending to the outer edge of the masonry shall be placed all around the bottom flange and have a slight slope to shed water away from the frame.
- E. Manhole covers shall be left in place in the frames on completion of other work at the manholes.

3.7 GREASE TRAP

- A. Grease traps shall be installed in accordance with the manufacturer's recommendations.
- B. The unit shall be placed on a minimum of 12 inches of compacted gravel on compacted subgrade.
- C. The joints of field-assembled sections shall be waterproof.
- D. Manhole riser sections, frames and covers shall be installed as required and detailed.

3.8 FIELD PERFORMANCE TESTS

- A. PVC joints shall sustain a maximum limit of 50 gallons per inch of diameter per foot per day per mile when field tested by actual infiltration conditions. All sanitary sewers which lie between 25' and 75' of a water supply well shall not exceed a leakage of 25 gallons per day per inch diameter of pipe per mile of sewer.
- B. These requirements will be met for every section (between manholes) of pipe; it is not a cumulative average over several sections of pipe. The low pressure air test as described in Section 3.5 of these specifications will be required for all sanitary sewer installations.

3.9 LEAKAGE TESTS FOR SEWER MANHOLES

- A. General. Leakage tests shall be made and observed by Engineer on each manhole. The test shall be an exfiltration test or vacuum test, made as described below.
- B. Preparation for Test. After the manhole has been assembled in place, all lifting holes and those exterior joints within 6 feet of the ground surface shall be filled and pointed with an approved non-shrinking mortar. The test shall be made prior to placing the self and invert and before filling and pointing the horizontal joints below the 6-foot depth line. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent blow out.
- C. Test Procedure. The manhole shall then be filled with water to the top of the cone section. If the excavation has not been backfilled and observations indicate no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily water-tight. If the test as described above is satisfactory, as determined by Engineer, or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and the measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed 1 gallon per vertical foot for a 24-hour period. If the test fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as directed by Engineer to bring the leakage within the allowable rate of 1 gallon per vertical foot per day. Leakage due to a defective section of joint, or exceeding the 3 gallon per vertical foot per day, shall be cause for the rejection of the manhole. It shall be the Contractor's responsibility to uncover the manhole as necessary and to disassemble, reconstruct or replace it as directed by Engineer. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.
- D. Backfilling. The test may be conducted either before or after backfilling around the manhole. However, if the Contractor elects to backfill prior to testing, for any reason, it shall be at their own risk and it shall be incumbent upon the Contractor to determine the reason for any failure of the test. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc., i.e., it will be assumed that all loss of water during the test is a result of leaks through the concrete. Furthermore, the Contractor shall take any steps necessary to assure Engineer that the water table is below the bottom of the manhole throughout the test.
- E. Infiltration Test. If the groundwater table is above the highest joint in the manhole, and if there is no leakage into the manhole as determined by Engineer, such a test can be used to evaluate the water-tightness of the manhole. However, if Engineer is not satisfied, the Contractor shall lower the water table and carry out the test as described herein before.
- F. Vacuum Testing
1. The vacuum testing system shall be a unit as supplied by P.A. Glazier, Inc. - Worcester, MA 01613 (508) 755-3849, Cherne Industries, Inc.-Minneapolis, MN 55436 (800-843-7584); IEQ industries-Ada, MI 49307 (800-544-9053), or approved equivalent.
 2. The testing shall be done immediately after assembly of the manhole and before backfilling. A 60 lb-in torque wrench shall be used to tighten the external clamps that

secure the test cover to the top of the manhole. All lift holes shall be plugged with an approved non-shrink grout. No grout will be placed in the horizontal joints before testing. All pipes entering the manhole shall be plugged, taking care to securely brace the plugs from being drawn into the manhole.

3. A vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to 9 inches. The manhole shall pass the test if the time is greater than 60 seconds for a 48" diameter manhole, 75 seconds for a 60" manhole, and 90 seconds for a 72" manhole.
4. If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn or the test shall be stopped, repairs made and all steps of the test repeated. Re-testing shall proceed until a satisfactory test is obtained.

3.10 SEWER PIPE JOINT TESTING

- A. The main sewer line and laterals shall be tested for leakage by the use of low-pressure air as approved by Engineer. The test length shall not exceed one length of pipe between two structures. Air test procedures may be dangerous and the Contractor shall take all necessary precautions to prevent blowouts.
- B. Pneumatic Plugs
 1. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be tested.
 2. Pneumatic plugs shall resist internal test pressures without requiring external bracing or blocking.
 3. All air used shall pass through a single control panel.
 4. Three individual hoses shall be used for the following connections:
 - a. From control panel to pneumatic plugs for inflation;
 - b. From control panel to sealed line for introducing the low pressure air;
 - c. From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.
- C. The following testing procedures shall be explicitly followed:
 1. All pneumatic plugs shall be seal tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The sealed pipe shall be pressurized to 5 psig. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.
 2. After the pipe has been backfilled and cleaned, pneumatic plugs shall be placed in the line at each manhole and inflated to 25 psi. Low-pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psi greater than the average back pressure of any ground water that may be over the pipe. At least two minutes shall be allowed for the air pressure to stabilize.

3. After the stabilization period (3.5 psi minimum pressure in the pipe), the portion of pipe tested shall be acceptable if the time required in minutes for the pressure to decrease from 3.5 to 3.0 psi (greater than the average back pressure of any ground water that may be over the pipe) is not less than the time indicated in the following table:

Minimum Pressure Drop Time

Pipe Size (in.)	Time (sec)
4	0.190L
6	0.427L
8	0.760L
10	1.187L
12	1.709L
15	2.671L

- D. Correction of Defective Work: If leakage exceeds the specified amount, the Contractor shall make the necessary repairs or replacements required to permanently reduce the leakage to within the specified limit, and the tests shall be repeated until the leakage requirement is met.
- E. Compliance with Agency Requirements: In the event of conflict between the leakage test requirements specified herein with the leakage test requirements of agencies having jurisdiction over all or any portion of the sewer system installed under this Contract, the more restrictive requirements shall govern.

3.11 CLEANING AND REPAIR

- A. The Contractor shall clean the entire sewer system of all debris and obstructions. This cleaning shall include, the removal of all formwork from structures, concrete and mortar droppings, construction debris and dirt. The system shall be thoroughly flushed clean and the Contractor shall furnish all necessary hose, pumps, pipe and other equipment that may be required for this purpose. No debris shall be flushed into existing sewers, storm drains and or streams.
- B. All work of cleaning and repair shall be performed at no additional cost to Owner.

3.12 FINAL INSPECTION

- A. Upon completion of the work, and before final acceptance by Engineer, the entire sewer system shall be subjected to a final inspection in the presence of Engineer. The work shall not be considered as complete until all requirements for line, grade, cleanliness, leakage tests and other requirements have been met.

3.13 AS-BUILT DRAWINGS

- A. As work progresses, record on one set of plans all changes and deviations from the Contract Drawings in size, line, and grade. Make sufficient measurements to accurately locate the completed work. Record the locations of any uncharted locations of utilities encountered during installation of the sewer. Deliver the final As-Built drawings to Engineer.

END OF SECTION

SECTION 33 4000 - STORM DRAINAGE SYSTEM

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Installation of new storm drain pipe, manholes and catch basins.
- B. Contractor shall coordinate work between all Contractors, sections, and trades required for the proper completion of the work.
- C. Contractor is responsible for all health and safety.
- D. Contractor is solely responsible for obtaining permits or approvals which may be required to perform the work of this section, including all costs, fees and taxes required or levied. Notify and obtain such permits or approvals from all agencies having jurisdiction prior to starting work.

1.2 REFERENCE STANDARDS

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR)
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Society for Testing and Materials (ASTM)
 - 1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A48 - Standard Specification for Gray Iron Castings.
 - 3. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
 - 5. ASTM A536 - Standard Specification for Ductile Iron Castings.
 - 6. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 7. ASTM C12 - Standard Practice for Installing Vitrified Clay Pipe Lines.
 - 8. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
 - 9. ASTM C55 - Standard Specification for Concrete Building Brick.

10. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
11. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.
12. ASTM C139 - Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.
13. ASTM C150 - Standard Specification for Portland Cement.
14. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes.
15. ASTM C270 - Standard Specification for Mortar for Unit Masonry.
16. ASTM C387 - Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
17. ASTM C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
18. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
19. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
20. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
21. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
22. ASTM C507 - Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
23. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
24. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
25. ASTM C700 - Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
26. ASTM C877 - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.
27. ASTM C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
28. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
29. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.

30. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.
31. ASTM C 1628 - Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets.
32. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
33. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120.
34. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
35. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
36. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
37. ASTM D2412 - Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
38. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
39. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
40. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
41. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
42. ASTM D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
43. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
44. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
45. ASTM D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
46. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
47. ASTM D4396 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Nonpressure Applications.

48. ASTM F402 - Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.
 49. ASTM F405 - Corrugated Polyethylene (PE) Tubing and Fittings.
 50. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 51. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
 52. ASTM F679 - Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 53. ASTM F714 - Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
 54. ASTM F758 - Smooth-Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage.
 55. ASTM F894 - Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.
 56. ASTM F1803 - Standard Specification for Poly (Vinyl Chloride)(PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter.
 57. ASTM F2306 - Standard Specification for 12 to 60 inch [300 to 1500 mm] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications.
 58. ASTM F2648 - Standard Specification for 2 to 60 inch [50 to 1500 mm] Annular Corrugated Profile Wall Polyethylene (PE) Pipe and Fittings for Land Drainage Applications.
- D. American Concrete Pipe Association (ACPA).
1. ACPA 01-103 - Concrete Pipe and Box Culvert Installation (latest revision and applicable supplements thereto).
- E. American Association of State High and Transportation Officials (AASHTO).
1. AASHTO H20 - Standard Specifications for HS-20, Highway Loading.
 2. AASHTO M105 - Standard Specification for Gray Iron Castings.
 3. AASHTO M198 - Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets.
 4. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe.
 5. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter.
- F. State of Connecticut Department of Transportation (ConnDOT)

1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.

1.3 SUBMITTALS

A. Shop Drawings:

1. Submit shop drawings, descriptive literature, or both, showing pipe materials and appurtenances to be furnished. Shop Drawings shall be submitted to Engineer for approval prior to ordering materials.
2. Shop drawings showing the configuration, dimensions, layout, and spacing of major and minor components such as pipe, joints, restraints, valves, and other proposed details of assembly. Show in large-scale details any unique assembly, and/or installation requirements.

B. Copies of manufacturer-provided installation instructions, operation instructions, and maintenance material for all equipment furnished under this Section.

C. Manufacturer's warranties and associated warranty registration data in Owner's name. Submit two (2) copies of each warranty to Engineer in the manufacture's/supplier's standard form or if there is no standard form available, in a form specified by Engineer.

D. As-Built Drawings.

1.4 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section. Use equipment of adequate size, capacity and quantity to accomplish the work of this Section in a timely manner.

B. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction.

C. Sample pipe for testing, when requested by Engineer, shall be furnished by Contractor in sufficient numbers. The Contractor and/or the pipe manufacturer shall make the facilities and services for making the load tests available.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage

1. Manufacturer shall package the pipe and other drainage materials in a manner designed to deliver the pipe to the Project Site neatly, intact, and without physical damage. Transportation carrier shall use an appropriate method to ensure the pipe is properly supported, stacked, and restrained during transport. Inspect materials delivered to site for damage; store with minimum of handling.

2. Unloading of the pipe and other drainage materials should be controlled so as not to collide with the other pipe sections or fittings, and care should be taken to avoid chipping or spalling, especially to the spigots and bells. For manhole sections, cone sections, bases, fittings and other precast appurtenances, utilize lifting holes or lifting eyes provided.

3. In cold weather conditions, use caution to prevent impact damage. Handling methods considered acceptable for warm weather may be unacceptable during cold weather.
4. Storage:
 - a. Store materials on site in enclosures or under protective coverings. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.
 - b. Pipe shall be stored on clean, level ground to prevent undue scratching or gouging.
 - c. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials under cover out of direct sunlight. Provide additional storage measures in accordance with the manufacturer's recommendations. Discard materials if storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.
 - d. Metal Items: Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.
 - e. Cement, Aggregate, and Reinforcement: As specified in Section 033200 – Site Cast-in-Place Concrete.
 - f. Store manhole units in an upright position.

PART 2 MATERIALS

2.1 GENERAL

- A. Products furnished under this Section which are damaged or found defective in any way prior to being set in place and final acceptance, may be rejected. Engineer may reject an entire lot of pipe should the sample pipe from such lot fail to meet requirements.

2.2 CONCRETE GRAVITY PIPE

- A. Pipe greater than 12 inches in diameter: Reinforced concrete pipe, ASTM C 76, Class 3.
- B. Class IV shall be required when cover is less than 12 inches.
- C. Pipe less than 12 inches in diameter: Concrete pipe, ASTM C 14, Class 3.
- D. Fittings and specials shall conform to the applicable requirements specified for the pipe.
- E. Gaskets and pipe ends for rubber gasket joint: ASTM C 443.

2.3 JOINT LUBRICANT

- A. As specified by pipe manufacturer, ANSI/AWWA C111/A21.11.

2.4 CATCH BASINS

- A. Reinforced precast concrete base, sump, transition, riser, corbel, and top: ASTM C913 for precast rectangular catch basins, ASTM C478 for precast circular catch basins. Type and dimensions as indicated on the Drawings.
 - 1. Concrete: 4,000 psi minimum, 4% - 7% entrained air.
 - 2. Reinforcement: ASTM C890. Steel bars, ASTM A615. Welded-wire fabric, ASTM A185. Additional reinforcing at openings.
 - 3. Precast sections shall consist of smooth sections in standard nominal inside diameters. All precast concrete sections shall be free from cracks, damaged joints, exposed reinforcing, aggregate pockets, spalls, and dimensional distortions or other irregularities. Lifting holes shall be filled with mortar, or other approved material.
 - 4. Openings or "knockouts" in precast units shall be located as shown on the Drawings and to accommodate the inflow and outflow pipe orientation required. Openings shall be sized sufficiently to permit passage of the largest outside dimension of pipe or fittings. Prior to ordering precast manhole bases, all angles between incoming pipes are to be field checked to incorporate possible line changes required in the field layout.
 - 5. External damp-proofing: Asphalt, ASTM D449, Type A.
- B. Gaskets for joints between sections: Butyl rubber, ASTM C 443.
- C. Grade Rings: ASTM C 478, precast reinforced concrete, 1 inch to 4 inch thickness, dimensions to match basin and top section.
- D. Frame and Grate.
 - 1. Cast iron: AASHTO M 105, Class 25 for frames and Class 30 for grates.
 - 2. Cast steel: ASTM A 27, Grade optional, thoroughly annealed.
 - 3. Structural Steel: ASTM A 36, or A 283, Grade B or better, as to quality and details of fabrication, except that in the chemical composition of the steel, the 2/10 of 1% of copper may be omitted.
 - 4. Grate type: ConnDOT "Type A" as indicated on the Drawings.
 - 5. Covers and gratings shall bear uniformly on their supports.
 - 6. Frame and grate shall be painted or galvanized, ConnDOT Form 816 M.06.03. Cast Iron frames and grates shall not be galvanized.

2.5 CONCRETE MANHOLE

- A. Precast concrete manhole risers, base sections, and tops: ASTM C 478. Precast manhole sections shall consist of smooth circular sections in standard nominal inside diameters. All precast concrete manhole sections shall be free from cracks, damaged joints, exposed reinforcing, aggregate pockets, spalls, and dimensional distortions or other irregularities. Lifting holes, when provided, shall be filled with mortar, or other approved material.
 - 1. Concrete: 4,000 psi minimum, 4% - 7% entrained air.

2. Diameter: 48-inches unless otherwise indicated.
 3. Base and first riser: Monolithic and built to the dimensions and requirements indicated on the Drawings.
 - a. Bottoms shall be integrally cast unless specialty bases (“Dog-House”) at points of connection to existing piping is indicated on the Drawings or otherwise proposed for use. Unless indicated on the Drawings, any special bases or riser used must be detailed in shop drawings and submitted for approval.
 4. Riser sections: As required to provide depths indicated.
 5. Top Section: Concentric-cone type, unless eccentric-cone or flat-slab-top type is indicated. Cones shall have the same wall thickness and reinforcement as riser sections. If required or called-for, flat slab shall be a minimum of 8-inches thick designed to carry AASHTO H-20 loading with one foot cover and conform to ASTM C478.
 6. External damp-proofing: Asphalt, ASTM D449, Type A.
 7. Openings or "knockouts" in precast units shall be located as shown on the Drawings and to accommodate the inflow and outflow pipe orientation required. Openings shall sized sufficiently to permit passage of the largest outside dimension of pipe or fittings. Prior to ordering precast manhole bases, all angles between incoming pipes are to be field checked to incorporate possible line changes required in the field layout.
- B. Gaskets for joints between manhole sections: Butyl rubber, ASTM C 443.
- C. Grade Rings: ASTM C 478, precast reinforced concrete, 1 inch to 4 inch thickness, diameter to match manhole and frame.
- D. Mortar: Packaged, ASTM C 387 or as Specified in Section 033200 – Site Cast-in-Place Concrete.
- E. Frame and Cover: Ductile Cast Iron, ASTM A536, Grade 60-40-18.]
- F. Frame and Cover: Grey Cast Iron, ASTM A48, Class 25B (Frame) and Class 30B (Covers), uncoated.
1. Cover: 26 inch diameter, non-vented with non-penetrating pickholes. Unless otherwise detailed or indicated, covers shall be cast with 1-1/2 inch wide, raised letters, indicating “STORM SEWER” unless other lettering is called-for.
 2. Frame and cover shall be supplied as a pair from the same manufacturer. Castings shall be of tough, even-grained iron, free from scale, lumps, blisters, sand-holes and other injurious defects, and of the size and type shown on the drawings. Frames and covers shall have machined bearing surfaces to seat firmly and prevent rocking and rattling under traffic loads. Before leaving the foundry, castings shall be thoroughly cleaned, subjected to hammer tests for soundness and given two coats of coal tar pitch varnish.
- G. Resilient connectors for joints between manhole and pipes entering manhole: Continuous boot of 3/8 inch minimum thickness neoprene, ASTM C 923 or ASTM C 990. Boots shall be either cast into the manhole wall or installed into a cored opening using internal

compression rings. Installed boot shall result in a water-tight connection meeting the performance requirements of ASTM C 443.

- H. Manhole Steps: ASTM C 478 and OSHA 29 CFR 1910.27, drop front or equivalent. Steps shall be nine inches in depth and at least twelve inches in width with an abrasive step surface.
 - 1. Composite Plastic-Steel: One-half (1/2) inch deformed steel reinforcing rod, ASTM A615, Grade 60, encapsulated in a co-polymer polypropylene plastic, ASTM D2146, Type II, Grade 16906.
 - 2. Steps shall be placed in vertical alignment as indicated on the Drawings. Steps shall be uniformly spaced not more than sixteen inches (16") on center, including the spacing between the top step and the manhole cover. Steps shall be embedded in the wall a minimum distance of 4 inches in either cast or drilled holes. Steps shall not be driven or vibrated into fresh concrete and shall withstand a pullout resistance of 2000 lbs when tested in accordance with ASTM C 497. Each step shall project a minimum of 5 inches from the wall measured from the point of embedment.

2.6 MASONRY UNITS

- A. Brick: ASTM C32 Grade MS or ASTM C62 Grade SW.
- B. Concrete block: Solid block, ASTM C139.

2.7 MORTAR

- A. Mortar: ASTM C 387.
 - 1. Portland Cement: ASTM C 150, Type I.
 - 2. Sand: ASTM C 144.
 - 3. Hydrated Lime: ASTM C 207.
 - 4. Water: Potable.
 - 5. Mix proportions for manhole rims and covers: 1 part portland cement, 2 parts sand, and 1/4 part hydrated lime by dry volume. Hydrated lime shall not exceed 10 percent by weight of the total dry mix. Quantity of water in mixture shall be sufficient to produce a stiff, workable mortar, but in no case shall exceed 5-1/2 gallons of water per sack of cement.
 - 6. Mix Proportions for invert construction: 1 part portland cement and 2 parts sand by volume. Quantity of water in mixture shall be sufficient to produce a stiff, workable mortar, but in no case shall exceed 5-1/2 gallons of water per sack of cement.

2.8 BEDDING

- A. Bedding for pipes: Unless otherwise directed by Engineer, bedding shall consist of screened gravel, maximum size 3/4 inches and minimum size 3/8 inches.

- B. Bedding for Catch Basins: Screened Gravel or Crushed Stone, well graded in size from 3/4 inch to 3/8 inch consisting of clean, hard, and durable fragments. No limestone shall be permitted.

PART 3 EXECUTION

3.1 PIPE INSTALLATION

- A. As soon as the excavation is completed to the normal grade of the bottom of the trench, the Contractor shall immediately place the bedding material in the trench. Then the pipe shall be firmly bedded in the compacted bedding material to conform accurately to the lines and grade indicated on the Drawings.
- B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions.
- C. Notch under pipe bells and joints, where applicable to provide for uniform bearing under entire length of pipe.
- D. Excavation, backfilling and compaction shall be as specified in Section 312310 - Earthwork of these Specifications.
- E. Maintain optimum moisture content of bedding material to attain required compaction density.

3.2 MANHOLES AND CATCH BASINS

- A. Manholes and Catch Basins shall be constructed at the locations and to the lines, grades and dimensions noted on the Drawings, or as required.
- B. Precast concrete construction shall be done in a manner to insure watertight construction and all leaks in precast concrete shall be sealed. If required, precast concrete shall be repaired or replaced to obtain watertight construction.
- C. Concrete barrels and cones shall be precast concrete sections.
 - 1. Bases shall be either precast with a barrel integrally cast with the base, or poured concrete suitably shaped by means of accurate bell-rung forms to receive the barrel sections. Manhole invert channels in manholes shall be formed in concrete.
 - 2. Precast manholes shall have an adjustment ring at the top of the cone to permit the frame and cover to meet the finished surface. This shall consist of courses of brick or reinforced grading rings not to exceed 11 inches.
- D. Stubs shall be short pieces cut from the bell ends of the appropriate size and class of pipe. Concrete stubs shall be plugged with brick masonry unless otherwise directed.
- E. Manhole inverts - shall conform accurately to the size of the adjoining pipes.
 - 1. Manhole inverts shall be constructed of concrete developing 4,000 psi with the concrete being placed to the spring line of the pipe form.

2. Smooth plastic pipe, matching the dimension of the outlet pipe, shall be used to form the invert.
 3. Side inverts and main inverts, where the direction changes, shall be laid out in smooth curves of the longest possible radius, which is tangent, within the manhole, to the centerline of adjoining pipelines.
 4. Invert shelves shall be graded to provide a 1-inch per 1-foot wash from the manhole walls.
- F. Manhole sections shall contain manhole steps accurately positioned and embedded in the concrete when the section is cast. Precast-reinforced concrete manhole sections shall be set so as to be vertical and with sections and steps in true alignment.
- G. All holes in sections used for their handling shall be thoroughly plugged with rubber plugs, made specifically for this purpose, or with mortar. The mortar shall be one part cement to 1-1/2 parts sand, mixed slightly damp to the touch (just short of “balling”), hammered into the holes until it is dense and an excess of paste appears on the surface, and then finished smooth and flush with the adjoining surfaces.
- H. The Contractor may, as an alternate to suitable nonshrink mortar joints, use premolded elastomeric-sealed joints for pipe into precast manhole bases.
1. All materials, accessories and construction methods used in making the joints shall be supplied or approved by the manufacturer of the premolded elastomeric-sealed joint.
- I. Openings for pipe and materials to be embedded in the walls of the base for these joints shall be cast in the base at the required locations during the manufacture of the base. Incorrectly cast and patched pipe openings will be rejected.
- J. Manhole risers and tops shall be installed using approved “o-ring” type, neoprene gaskets for sealing joints. Units shall be installed level and plumb. Water shall not be permitted to rise over newly made joints nor until after inspection as to their acceptability. All jointing shall be done in a manner to insure water tightness.
- K. Openings shall be provided in the risers to receive entering pipes. These openings may be made at the place of manufacture. The openings shall be sized to provide a uniform 1 inch maximum annular space between the outside of the pipe wall and the opening in the riser. After the pipe is in position, the annular space shall be solidly filled with nonshrink mortar. Care shall be taken to assure that the openings are located to permit setting of the entering pipe at its correct elevation as indicated.
- L. Openings, which are cut in the risers in the field, shall be carefully made by coring so as not to damage the riser. Damaged risers will be rejected and shall be replaced at no additional expense to the Owner.
- M. Where required by the Drawings, a slot and opening shall be cast in the catch basin wall suitable for mounting the cast iron hood and discharge pipe. The hood hinge may be furnished to the precast supplier by the Contractor for incorporation into the casting during manufacture.

3.3 BRICK MASONRY

- A. Brick Masonry Construction shall be done in a manner to insure watertight construction and all leaks in brick masonry shall be sealed. All workmanship shall conform to the best standard practice and all brick masonry shall be laid by skilled workmen.
- B. All beds on which masonry is to be laid shall be cleaned and wetted properly. Brick shall be wetted as required and shall be damp but free of any surface water when placed in the Work. Bed joints shall be formed of a thick layer of mortar, which shall be smoothed or furrowed slightly. Head joints shall be formed by applying to the brick to be laid a full coat of mortar on the entire end, or on the entire side as the case requires, and then shoving the mortar covered end or side of the brick tightly against the bricks laid previously. The practice of buttering at the corners of the brick and then throwing the mortar or crappings in the empty joints will not be permitted. Dry or butt joints will not be permitted. Joints shall be uniform in thickness and shall be approximately 1-1/4 inch thick.
- C. Brickwork shall be constructed accurately to dimensions and brickwork at top of manholes shall be to the dimensions of the flanges of the cast-iron frames.
- D. Joints on the inside face of walls shall be tooled slightly concave with an approved jointer when the mortar is thumbprint hard. The mortar shall be compressed with complete contact along the edges to seal the surface of the joints.
- E. All castings to be embedded in the brickwork shall be accurately set and built-in as the Work progresses. Cast-iron frames and manhole covers shall be well bedded in mortar and accurately set to finished graded indicated or as directed.
- F. Water shall not be allowed to flow against brickwork or to rise on the masonry for 60 hours after it has been laid, and any brick masonry damaged in this manner shall be replaced as directed at no additional expense to the Owner. Adequate precautions shall be taken in freezing weather to protect the masonry from damage by frost.

3.4 CONCRETE MASONRY UNITS

- A. Concrete Masonry unit construction shall be soaked in water before laying. As circular concrete block walls are laid-up, the horizontal joints and keyways shall be flushed full with mortar. As rectangular blocks are laid-up, all horizontal and vertical joints shall be flushed full with mortar. Plastering of the outside of block structures will not be required. The joints in precast units shall be wetted and completely mortared immediately prior to setting a section. No structure shall be backfilled until all mortar has completely set.

3.5 MANHOLE STEPS

- A. Placement of steps into the precast walls shall be by a proven method as recommended by the supplier of the precast manhole sections. Details of the steps and method of placement shall be submitted for approval.
- B. Plastic steps shall be placed into the wet concrete wall during manufacture or if designed for press fit installation shall be driven into a wall opening according to the manufacturer's specifications. Steps shall not be mortared into place after the concrete has set.

- C. All manholes, catch basins, lawn inlets, etc., which are in excess of five feet in depth, shall be constructed with standard aluminum steps, spaced at 12-inch on center.

3.6 DROP INLETS

- A. Drop inlets shall be constructed to the lines, grades, dimensions and design at the locations indicated on the plans or as required.
- B. Construction shall conform to requirements outlined in Section 033013 - Site Cast-in-Place Concrete.
- C. Engineer may permit brick or concrete masonry construction. If this alternate is being employed, construction shall be done in accordance with paragraphs 3.04 or 3.05 in this Section.

3.7 CASTINGS

- A. Cast-iron frames for grates and covers shall be well bedded in cement mortar and accurately set to the grades indicated or as directed. The frames shall be encased with a thick cement-mortar collar around the entire perimeter of the frames.
- B. All voids between the bottom flange shall be completely filled to make a watertight fit. A ring of mortar, at least one-inch thick and pitched to shed water away from the frame shall be placed over and around the outside of the bottom flange. The mortar shall extend to the outer edge of the masonry all around its circumference and shall be finished smooth. No visible leakage will be permitted.
- C. Structures within the limits of bituminous concrete pavement shall be temporarily set at the elevation of the bottom of the binder course or as ordered. After the binder course has been compacted, these structures shall be set at their final grade. Backfill necessary around such structures after the binder course has been completed shall be made with Class A concrete unless otherwise ordered.

3.8 CLEANING

- A. At the completion of the Work, clean all piping, structures and open drainage courses, through and to which water from this construction is directed, to the satisfaction of Engineer.

3.9 AS-BUILT DRAWINGS

- A. Contractor shall be solely responsible for complying with the requirements of local permitting authorities for preparation and submittal of as-built drawings. The requirements for the preparation of as-built drawings as defined herein shall be considered the minimum requirements of Engineer, but shall in no way relieve Contractor from satisfying the requirements of local permitting authorities.
- B. As work progresses, record the following on two (2) sets of Drawings:
 - 1. All changes and deviations from the design in location, grade, size, material, or other feature as appropriate.

2. Any uncharted locations of utilities or other subsurface feature encountered during installation, including the characteristics of such uncharted utility or subsurface feature such as utility type, size, depth, material of construction, etc.
- C. Recording of changes shall be clearly and neatly marked in red pen or pencil. All changes shall be noted on the appropriate Drawing sheets.
- D. Make measurements from fixed, permanent points on the Project Site to accurately locate the work completed. Such measurements shall consist of at least three (3) ties showing the distance of each item relative to each of the fixed, permanent points.
- E. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall also contain any additional information required by Engineer.

END OF SECTION